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Engineering Education and the Strive for Quality at a South African University

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Abstract

Since 1997, South Africa's Department of Higher Education and the Council on Higher Education have collaborated to enhance the quality of higher education. While some commend these efforts, believing that educational standards have progressively improved, others argue that institutions are still falling short in delivering quality education. This study investigates the engineering program to assess the quality of education students receive. Employing a qualitative case study approach, data was collected through open-ended questionnaires and subsequently coded into three themes: decolonised education, responsive education, and employability. The findings revealed that 30.70% of participants perceived their education as high quality, whereas 69.30% felt it was lacking. Participants cited innovation, throughput rates, employable skills, and responsiveness as indicators of quality or its absence. In response to suggestions for improving education quality, three additional themes emerged: decolonisation, marketability, and contextual responsiveness. This research follows a 2017 study aimed at evaluating improvements in educational quality. The study concludes that the Engineering Council of South Africa and educational institutions must review their programs to ensure they develop the skills necessary for the evolving workplace, particularly in light of the transformative changes brought about by the Fourth Industrial Revolution.

Keywords: quality education, engineering education, higher education, learning

Introduction

Quality assurance in higher education is not a new subject; the sector has grappled with

issues of quality for centuries. This research on the quality of engineering education was informed by previous studies conducted within the South African higher education system. The initial study highlighted significant challenges in teaching and learning quality across six South African universities, prompting further contextual research into specific programs to validate these findings. The engineering program was selected for its critical role in the Fourth Industrial Revolution and its impact on improving quality of life. This study also aimed to further explore the phenomenon of quality in South African higher education.

Defining quality education is complex, as it varies across disciplines and contexts. Heystek and Minnaar (2015) argue that terms such as academic standards, degree standards, student assessment, and accountability are often used interchangeably with quality in higher education. The increasing demand for higher education in Africa, particularly in South Africa, has intensified pressure on universities to deliver high-quality education, especially given the rising dropout rates. Between 2006 and 2013, student enrollment in South African higher education grew by 194,000, reaching a total of 975,837 students by 2016 (Council on Higher Education, 2018). By 2023, this number had increased to over 1.1 million students (Department of Higher Education and Training, 2023). However, the first-year dropout rate remains a significant challenge, with recent studies indicating a stubborn rate of 60% (Johnson, 2023).

The demand for quality education is driven by various stakeholders, including government organisations and student unions, who seek better educational experiences that offer value for money, especially amid changing university funding structures (Fomunyam, 2016). Chapman and Adams (2002) argue that quality education extends beyond instructional activities to include lecturer-to-student ratios, lecturer training, student engagement, and performance in assessments, which influence graduation rates, employability, and workplace performance. This multifaceted nature of quality assurance makes it a challenging task. However, the question of what constitutes quality education remains open for debate.

Recent studies have provided updated definitions and frameworks for understanding quality education. According to UNICEF (2023), quality education includes inclusive and equitable learning opportunities that promote lifelong learning and ensure that all students achieve relevant and effective learning outcomes. This definition emphasises the importance of inclusivity and equity in providing quality education. Similarly, the Global Goals (2023) define quality education as ensuring that all learners acquire the knowledge and skills needed to promote sustainable development, including education for sustainable lifestyles, human rights, gender equality, and global citizenship. This perspective highlights the transformative potential of education in fostering global citizenship and sustainable development. In South African higher education, the Council on Higher Education (CHE), is responsible for quality assurance, often provides guidelines or frameworks for teaching and learning. The previous study engaged the second cycle framework for quality assurance (Council on Higher Education, 2012), which provided the basis for quality education in South African universities. This framework remains faithful to the mission of the CHE and the Higher Education Quality Committee (HEQC) to ensure a quality-driven higher education

system that contributes to socio-economic development, social justice, and innovative scholarship in South Africa. Building on the first cycle, the second cycle HEQC aimed at supporting the development, maintenance, and enhancement of the quality of public and private higher education provision. This was to enable a range of stakeholders to benefit from effective higher education and training. The central objective of the HEQC is to ensure that providers deliver high-quality education, training, research, and community service, producing socially useful and enriching knowledge and a relevant range of graduate skills and competencies necessary for social and economic progress. The Fourth Industrial Revolution (4IR) has brought significant changes to the workplace, necessitating a review of educational programs to develop skills relevant to this new era. The integration of advanced technologies such as artificial intelligence, robotics, and the Internet of Things (IoT) into various industries requires graduates to possess new competencies and adaptability. According to the Department of Higher Education and Training (2023), there is a growing emphasis on incorporating digital skills and innovation into curricula to prepare students for the future workforce. Recent statistics indicate that student enrollment in South African higher education grew to over 1.1 million by 2023 (Department of Higher Education and Training, 2023). However, the first-year dropout rate remains a significant challenge, with a stubborn rate of 60% (Johnson, 2023). This highlights the need for quality education frameworks that not only focus on academic standards but also on student retention and success.

Recent studies have emphasised the importance of quality assurance frameworks in higher education. For instance, a 2023 review by Mireku and Bervell highlights the need for internal and external mechanisms to improve education quality in sub-Saharan Africa, identifying gaps in funding, staff training, and policy implementation as major challenges. Another study by Jasti et al. (2022) discusses the evolution of Total Quality Management (TQM) models in higher education, emphasising the need for modern teaching methods and infrastructure to support quality assurance. This studies further stress the need for quality. The demand for quality education is driven by various stakeholders, including government organisations and student unions, who seek better educational experiences that offer value for money, especially amid changing university funding structures (Fomunyam, 2016). Chapman and Adams (2002) argue that quality education extends beyond instructional activities to include lecturer-to-student ratios, lecturer training, student engagement, and performance in assessments, which influence graduation rates, employability, and workplace performance. This multifaceted nature of quality assurance makes it a challenging task. However, the question of what constitutes quality education in South Africa is still a debate.

In the bit to further fine-tune the path to quality education, the Council on Higher Education (CHE), developed a new framework for quality assurance building on the previous framework and its indicators of fitness for purpose, value for money and transformation. The latest framework, the Quality Assurance Framework (QAF) for Higher Education in South Africa (Council on Higher Education, 2022), outlines seven key markers of quality: Institutional Responsibility and Accountability for Internal Quality Assurance (IQA), Integration, Fitness for Purpose and Fitness of Purpose, Differentiation, Simplification, Collaboration, and Innovation. These markers are

designed to ensure that higher education institutions deliver education that meets the needs of students and society, aligns with national development goals, and adapts to the changing demands of the Fourth Industrial Revolution. The seven principles of the 2022 QAF's Institutional Responsibility and Accountability for IQA, Integration, Fitness for Purpose and Fitness of Purpose, Differentiation, Simplification, Collaboration, and Innovation align with the previous framework's focus on fitness for purpose, value for money, and transformation. Fitness for Purpose and Fitness of Purpose ensure that educational programs meet their intended goals and societal needs. Value for money is addressed through markers like Efficiency and Accountability, ensuring that resources are used effectively to provide high-quality education. Transformation is supported by markers such as Innovation and Differentiation, which encourage institutions to adapt and evolve in response to new challenges and opportunities, particularly those presented by the Fourth Industrial Revolution.

This constant drive for the improvement of quality comes on the backdrop poor student performances and high dropout rates particularly in the engineering disciplines. To illustrate this better, National Advisory Council on Innovation (NACI, 2023), states that between 2017 and 2022, science, engineering, and technology (SET) fields continued to see the highest number of student enrolments in South African higher education. The numbers were 310,000 for 2017, 320,000 for 2018, 330,000 for 2019, 340,000 for 2020, 350,000 for 2021, and 360,000 for 2022. Despite these high enrolment rates, only 50,000 and 65,000 students graduated in SET fields in 2017 and 2022, respectively. This means that less than twenty percent of the students were able to graduate (NACI, 2023). What, therefore, are the reasons for poor throughput rates, especially in engineering education in South Africa remains a question to be answered. Fomunyam (2021) argued that there is a significant shortage of engineers in South Africa, and engineering has been listed as a scarce skill in the country for the past decade. This paper seeks to interrogate the quality of engineering education in a South African university as a way of explaining this phenomenon. To do this, it is critical to clearly articulate how the data used in offering this explanation was generated.

Methodological idiosyncrasies

Creswell and Creswell (2022) argue that research design and methodology serve as a roadmap for researchers, detailing the steps they will take throughout their study. Methodological idiosyncrasies in this paper articulate the approach, design, and instruments used to generate data. This research was designed as a qualitative case study of engineering education in a South African university. The qualitative approach to research aims to explore every detail about an issue or a case, unearthing the quality of what is being researched (Creswell & Creswell, 2022). A qualitative approach was used to generate rich and in-depth data on the quality of engineering education in a South African university. Maxwell (2013) adds that qualitative research has goals that can be realised and specific outcomes that meet a need. Its intellectual goal is to understand or explain with certainty the quality of engineering education in a South African university. The research is therefore justifiably qualitative to explore in-depth details

about quality education. The case study approach was used in line with qualitative research. Yin (2018) defines case study research as "an in-depth study of one particular case or group of cases in which the case may be a person, a school, a group of people or organisations, an organisation, a community, an event, a movement, or geographical unit" (p. 40). This means that a case study can either be an entity or a group of entities combined to form a case. In this paper, a university in South Africa was selected as a case study because it recorded almost the lowest number of graduates in the areas of science, engineering, and technology for the year 2016 and 2017. The first study was conducted to explore the quality of the program, and this is being conducted to explore if there have been any improvements. In this instance, the case under study is a South African university, and the unit of exploration was the engineering program. This aligns with Fomunyam (2021), who argues that a case study can either be a group of people or an organisation. With the qualitative case study approach, data was generated using open-ended questionnaires. Creswell and Creswell (2022) argue that open-ended questionnaires are used to elicit the feelings, beliefs, experiences, perceptions, or attitudes of a sample of individuals. An open-ended questionnaire asks questions that require the respondent to provide whatever information they believe necessary. Open-ended questionnaires generate data similar to interviews because they enable further probing by allowing respondents to provide additional information about their answers (Creswell & Creswell, 2022). The researcher administered the questionnaires to about 900 students in the engineering faculty within the university, but only 320 students (both undergraduate and postgraduate) responded. The questionnaires contained four major questions: what do you understand by quality education; do you think you are receiving quality education in your university; provide reasons or further explanations for your answer; and what do you think can be done to improve the quality of education in your program? The findings are presented and analysed in the following section.

Findings

The large and detailed volume of data necessitated its coding and categorisation into themes aligned with the research questions. This approach was essential since the research focused on four primary questions. Consequently, the data from each question was systematically coded and categorised into themes that reflect the participants' overall views. Direct quotations from participants provided justification for each theme, effectively answering each question. Specifically, the coding and categorisation of the data generated from the first question resulted in three key themes: skills-driven education, responsive education, and value for money.

Skills driven education as the first theme explains students' understanding of quality education as centred on the skills, curriculum, teaching, learning, and the general stratosphere of higher education should help students develop. For it to be said that the engineering education offered by the university is of high quality it must be geared towards the development of skills that fit the times. Speaking to this one of the participants pointed that "South Africa has witnessed massive skills shortages which explains why they offer visas to foreigners with critical skills and engineering has been

in the list for almost a decade. Quality engineering education must be skills driven to help address the skills gap". From this perspective, a skilled graduate would be one with a multiplicity of skills. Supporting this claim another participant added that "quality engineering education is one that help develop skills that align to the dictates of the fourth industrial revolution. Graduates must have skills that are in high demand in their fields and be well versed with the operations in the marketplace". To the participants, skills driven education is considered the hallmark of quality and if students are not developing vital skills, then whatever they are learning cannot be considered of high quality. Another participant further stated that "to me as an engineering student quality education is about practical skills. You find a lot of graduates who know theory but zero practical. This is why I chose a UoT to study. Students must learn the practical aspects of the theory and develop skills". To the participants for engineering education to be considered quality within the context of this research, it must be oriented towards skills development. Students must develop all types of skills to be considered to have acquired quality education.

Responsive education as the second theme in response to the first question about the meaning of quality centres on the ability of engineering education to be responsive to local issues. Responsiveness is the ability of education to speak to the socio-political realities. Throwing more light on their understanding of quality, the participants stated that "South Africa has a lot of issues from the high crime rates to unemployment and infrastructural issues. Load shedding has been an issue for years. Engineering education must address these issues for it to be considered of high quality". Another participant added that "South Africa used to be amongst the top in innovation but that has been on the decline for years. Engineering education must respond to the challenges of innovation and shape the future of South Africa". Responsiveness is at the very centre of improving the quality of life and if this is going to happen then engineering education must be responsive to be of quality. Another participant supported this understanding of quality by stating that "engineering is at the heart of every society and is responsible for shaping the future. America and China are leading the world today because of their engineers and their ability to respond to local issues. We must be able to do that as well". Responsiveness or the degree of responsiveness in this case determines whether the education is of quality or not.

Value for money as the third theme explains students' understanding of quality in engineering education as a function of what they get in response to what they paid to get it. What you pay for a thing determines the value you place on it. Students believe they should be getting their money's worth for the education to be considered quality. In line with this, one of the participants stated that, "graduates must be able to function in the engineering world upon completion of their studies. ECSA has testified year on year that there is a shortage of engineers in South Africa although engineering education admits more students than any other program. The shortage of engineers in this case is not about those with an engineering degree or diploma but about those who can fully function as engineers". Another participant added that "many graduates can't find employment meaning they are not getting value for their money. For engineering education to be considered to be of high quality it must offer value for money". Value

for money is vitally important as a descriptor of quality education and engineering education must offer value for money.

In response to the second question whether they thought their education was of quality or not, 232 students responded negatively, while 98 responded positively. As such, 72.5 percent of the participants thought that their education lacked quality while 27.5 percent thought that their education was of high quality. This indicates a 3.20 percent decrease in quality based on the findings of the previous study which stood at 69.30 percent believing that their education lacked quality. The follow up question which demanded that participants should justify their claims resulted in four themes: critical skills, responsiveness, innovation and dropout rates.

Critical skills was the first reason advanced by the majority of the participants to justify their claim that their education lacked quality. The participants posited that most graduates lacked critical skills and they themselves are not being taught any critical skills. In line with this one of the participants stated "my friend graduated a few months ago and has been looking for job. Meanwhile we are told there are a shortage of engineers. He has gone for several interviews to no avail. He told me another of his classmates is experiencing the same challenges. We lack the critical skills the employers are looking for. Do they employ those who were trained better". Another participant added that "we have been told about the fourth industrial revolution and the changes it is creating but we are not being taught any of the skills they said is vital in this age. This means something is wrong with our education. Another participant further added that "engineering graduates are failing to find work and most of them can't even employ themselves. They lack the skills which the labour market needs, or the skills to employ themselves and become useful in the society. If the education had quality, they would have been taught what to do". Lack of critical skills to these participants constitute an explanation for the lack of quality.

Responsiveness as the second theme explaining the lack of quality was anchored on the idea that South African engineers are failing to handle local challenges like their counterparts elsewhere in Europe and Asia. Some of the participants believed that they were being trained according to the needs of the countries of the colonial masters rather than the needs of present-day South Africa. Throwing more light on this, one of the participants pointed out that "many South Africans live in poverty, and engineers should help them live better. However, our engineers are not meeting this goal. They have not fixed the housing issues for many South Africans, nor have they resolved the energy problems in the country. Only when our graduates can solve these issues can we say our engineering education is good". Another participant concluded that "graduates shouldn't just be taught to find jobs, but also to innovate and boost the economy, and by doing so, improve society. Engineering graduates should aim to be new entrepreneurs who want to bring change to society, rather than moving from company to company looking for jobs they may never get because their training isn't sufficient". The inability of engineering education to train engineers who can respond to societal needs speaks of poor quality or the lack thereof.

On the other hand, there was another group of participants who believed that they were getting the best education available to aspiring engineers. The reasons advanced for this position were summed up into two themes. Innovation and dropout rates were used as justification for the claim that the education they were receiving was of high quality. Innovation was the first theme justifying the quality of education they were receiving. Throwing more light on this, one of the participants stated that "the last entrepreneurship day, there were more than 20 engineering students there showcasing their innovations. For them to be able to do that, the university must be doing something amazing". Another participant added that "the number of companies providing seed funding to students here is a testament to their belief in the quality of education we are getting. Also, the number of students maximising their funding shows we are being taught the right way". Another participant further added that "some engineering graduates and students from this university have been able to produce some amazing designs and innovations which have amazed a lot of people. Some have developed solar car models, others have developed new models of generating energy, and others have developed several computer applications and programs which function excellently. This can only be the product of quality education". The ability of students from the engineering faculty to innovate in different aspects is a testament to some of the participants that their education is of high quality. The second theme used to justify the existence of quality in engineering education was dropout rates. Some of the participants believed that the rate at which students were dropping out of the program was an indication of how tough the program is. Speaking to this one of the participants stated that "in our first year we were hundreds in our department. Now that we are in our final year about half have dropped out. The fact that many can't cope speaks to the quality of the program. Another participant added that "since we started with this program two years back, more than thirty percent of the students have dropped out. If there were no quality and everything was just done anyhow, they would still be here". Another participant concluded that "the only reason only a few students graduated from this program in the last graduation speaks volumes. The only reason several students are dropping out is because they are not able to measure up with the quality of the program". The high number of students dropping out of the program was seen as a testament to the quality of education they were receiving.

The response to the last question on what participants thought the department or university needed to do to improve the quality of the engineering program, was categorised into three themes: decolonisation, fourth industrial revolution and contextual responsiveness. The participants believed that the program needed to be further decolonised to address more local issues. Decolonisation was seen as the primary way of ridding the program of all the vestiges of colonialism. Speaking on this, one of the participants stated that "in some of the courses we are still studying things that were written be dead white men years ago. This needs to change and the focus needs to be centred on relevance so it can be fit for purpose". Another participant added that "decolonising engineering education would see to it that we are free from colonial mindsets and are able to change the society we live in. If our mindset doesn't change, we can't change our societies. The program must be further decolonised". Another participant concluded that "a lot has been said about decolonisation, but little has been

done to change things. Both the curriculum and pedagogy need to be addressed. Students should be taught and assessed in ways that should empower them and not the way the whites told us to do it years ago". To the participants, every aspect of the program must be decolonised to improve quality.

The fourth industrial revolution was the second theme that emerged in the strive to improve quality. To the participants we are in the era of the fourth industrial revolution and the program must reflect this. Expounding on this, one of the participants stated that "the fourth industrial revolution demands new a set of skills and these skills both soft and hard must be inculcated into the program to improve the quality. We know that the future is changing rapidly, and students must be trained to fit in the space". Another participant added that "there is a lot of automation and transformation happening as a result of the fourth industrial revolution and the program must take this into consideration". Another participant further added that "we haven't been taught any about the fourth industrial revolution even though it's the age we live in. We need to be taught about it progressively so we can know where society is going and keep up with it". Centring the engineering program around the fourth industrial revolution would improve the quality of the program and keep the participants up to date with the happenings they will face upon graduation.

The last theme pointed towards another issue which needs to be taken into consideration to improve the quality of the engineering education program. Contextual responsiveness was seen as another avenue through which quality can be improved. To the participants, contextual responsiveness must be put at the heart of the program since a majority of the students should be functioning within the context. Justifying this, one of the participants stated that "improving the quality of engineering education would mean ensuring that engineers are able to deal with local challenges like poverty, hunger, housing, energy amongst others. They should be able to address the contextual needs of the immediate societies from which they come from". Another participant added that "the university should make sure its programs and students can easily deal with local challenges, like those in the university or the nearby community, before tackling national and global problems. Handling these smaller issues will give students a chance to learn and grow. For example, problems like student housing, crowded classrooms, and lack of resources should be addressed by engineering students. This approach will help improve the quality of their education". Contextual responsiveness is therefore at the heart of improving the quality of education since these engineers would grow and become better by handling the simple or non-complex local challenges.

Discussion

Based on the findings, quality in education is understood from three perspectives: skills-driven education, responsive education, and value for money. When these themes are compared to the key indicators of quality outlined by the Council on Higher Education (2012; 2022), it is evident that the participants' views align closely with these indicators. Skills-driven education involves integration, fitness for purpose, and differentiation, which is critical as the South African higher education system aims to

produce more skilled graduates to address the country's skills gap (Fomunyam, 2017a, 2017b). This transformation implies modifying the curriculum and teaching methods to ensure the engineering programme is fit for purpose. The Department of Higher Education (1997) identifies four fundamental principles of higher education in South Africa: meeting individuals' learning needs and aspirations through lifelong intellectual development; addressing society's development needs and providing the labour market with high-level skills and expertise necessary for a modern economy; contributing to the socialisation of enlightened and critical citizens; and promoting the creation, sharing, and evaluation of knowledge. Particularly in the engineering sector, skills-driven education would ensure that students develop intellectual capacities within the context of evolving high-level skills and expertise needed for growth in South Africa and globally. Responsive education addresses transformation, as outlined by the Council on Higher Education (2012). Responsiveness fosters transformation not just of society, but also of individuals. For engineering education to transform both people and society, it must be responsive. Value for money aligns with the value for money principle in the second cycle quality assurance framework and involves collaboration and innovation. Graduates' employability indicates that they have received value for their money (Cheng, 2011). Employability is part of this as it reflects the value students receive from their education. Fomunyam (2018) asserts that fitness for purpose, value for money, and transformation are globally recognised indicators of quality. If students' perceptions of quality align with these indicators, their views on the quality of education in their context are highly relevant. Approximately 27.5% of participants believed their education was of high quality, while about 72.5% felt it lacked quality (Teferra, 2015; Cloete, 2016). This has been confirmed by Fomunyam (2016, 2018), who argue that the quality of undergraduate education is questionable. Research findings indicate that critical skills, responsiveness, innovation, and dropout rates justify the perceived lack or presence of quality. Cloete (2016) attributes the lack of quality to various factors, including the failure to develop students' intellectual talent. The inability to harness the potential of a significant portion of the population entering higher education contributes to high-level skills shortages. Nevertheless, several institutions have reported innovations in their engineering programmes. According to Fomunyam (2017b), engineering education in South Africa has seen noteworthy innovations, though further measures are needed to expand these efforts. Decolonisation, the fourth industrial revolution, and contextual responsiveness emerged as alternative ways to improve the quality of engineering education in South Africa. Decolonisation would free the curriculum and teaching methods from colonial influences (Fomunyam, 2017b), while contextual responsiveness would enable graduates to address the legacies of colonialism evident in society. Engaging with the fourth industrial revolution would ensure graduates can contribute to social transformation and national development, as well as guarantee public returns on higher education (Fomunyam, 2017a; Motahhari-Nejad, Ghourchian, Jafari, & Yaghoubi, 2012). Society now demands engineers who view technology not only as an economic tool but also as a means to improve quality of life and address current and future societal challenges. Decolonisation, the fourth industrial revolution, and contextual responsiveness would help new engineering graduates align with these trends (Apelian, 2007).

Conclusion and Recommendations

Quality education is not a new discourse in South Africa, but the drive to improve quality has and will remain a continuous process. The three quality indicators provided by the Council on Higher Education to guide teaching and learning and ensure that the education being offered is of high quality are fitness for purpose, value for money, and transformation. These indicators do not only resonate with quality discourse in South Africa but also internationally. From the findings of the study, it is clear that student constructions of quality resonate with these indicators of quality, making their assessment of their education critical. While some believe that the education they are receiving is of high quality, the majority believe it lacks quality. Those who think it is of high quality argued that students and graduates were constantly innovating and developing new patterns as well as collaborating with companies and government agencies to improve the quality of life in South Africa. They also argued that the number of students who are able to complete the program is indicative of the quality and rigorousness of the program. It was also clear that decolonisation, the fourth industrial revolution, and contextual responsiveness were seen and understood as different ways of improving the quality of engineering education. From the findings of this research, three key conclusions can be drawn: firstly, engineering education needs an intervention to address the high dropout and low throughput rates as a way of addressing the lack of engineers in South Africa. Secondly, universities need to review their engineering curriculum to ensure the training of graduates who understand the context wherein they are to function, as well as graduates who can create jobs for themselves and not remain unemployed when they cannot find work. Lastly, universities need to work continuously to improve the quality of engineering education within their various universities by ensuring that they consider the key quality indicators, be it those articulated by the Council on Higher Education or those articulated from research within the field. Drawing from this, this paper concludes with two key recommendations: The Engineering Council of South Africa needs to re-evaluate some engineering courses and programs to ensure that they are up to date and meet international standards, as well as ensure that they address industry and societal needs, thereby making engineering graduates employable and marketable. Lastly, the entire criteria, teaching approaches, support mechanisms, amongst other things, of the engineering program need to be reviewed by universities to ensure they offer value for money, are fit for purpose, and guarantee the transformation of both the individual and society.

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