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# Excellence and Relevance in Engineering Education in 21st Century Africa

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**Abstract**

In 21st century Africa, advocating for excellence and relevance in education has brought a significant change in engineering education (EE). Though, EE have not recorded much success in its achievement in African engineering institutions, as this may be connected to shortage of learning facilities, poor assessment of curriculum programmes, and lack of institutional support. With much debate on accomplishing excellence and relevance in EE, African EE are far from attaining the position of 21st century engineers; hence the crux of this paper. This paper was guided by Lev Vygotsky's social constructivism theory, focusing on learning mainly takes place in social and cultural settings, rather than only an individual. This paper takes a look at the broad concepts of excellence and relevance in EE. Specifically, it explores how these concepts can shape EE and the role it plays in shaping EE, as well as its implications for the 21st century Africa. Thus, to address these gaps, recommendations such as evaluation of alternative teaching strategies, revived faculty and students' collaborations, reconstructing engineering curriculum plus courses, rejuvenated EE advisory boards as well as inventing multi-disciplinary symposiums for 21st century skills were advocated.

**Keywords:** Africa, engineering education, excellence, relevance, 21st century

## INTRODUCTION

The demand for engineering graduates with skills has increased progressively across the globe, and engineering education (EE) as a field of scholarship continues to advance towards the 21st century skills. For engineers to thrive in fourth industrial revolution (4IR) era, scholarly debates have focused on how to bring excellence and relevance in EE in 21st century Africa. To an extent, engineering educators as well as professionals, has greatly influence curriculum upgrade and course modules, aligned with significant industrial skills demands, thus moving engineering fields in excellence and relevance (OECD, 2016; WEF, 2016; Falck et al., 2016; Forster et al., 2017). It is an imperative to draw out excellence and relevance in EE in as it has a deep domain of broad professional skills and knowledge content leading to engineering students' skill development. Consequently, EE has taken responsibility of imparting engineering theory and practices among engineering students, as industrial professionals are laying emphasis and advocating that engineering graduates are expected to acquire certain skills from the universities rather than when they are on employment jobs (Sun, 2015; Lima, 2017). Industrial professionals have agitated in recent times seeking for employees to display their university training along with added skills, yet a lot of universities do not inevitably keep pace with this trend (Felder et al., 2016; Elrod et al., 2017). The notion of being an engineer professional result from training from the university, which usually do not always align with industrial demands. Curriculums in EE are not connected with industries and collaboration research project in order to bring new ideas and methods that will stand as a trademark of an aspiring engineer of the 21st century Africa (Koretsky et al., 2019).

However, educating an engineering students in the 21st century requires additional influence from industrial professionals to participate in the visions of the 21st century Africa engineering practices, as this will be a guiding principles to shape engineering to restore excellence and relevance in EE (Thom-otuya et al., 2016). Restoring EE in defining excellence and relevance in 21st century, may accelerate technological modernization through interconnected global interactions, involving multidisciplinary diversity (Brown et al., 2015; Makio-Marusik, 2017). However, suggestions have been put forward to upgrade EE curriculum based on skills, creativity, competence and ethical standards as well as a combination of social personalities. Several studies focused on engineering technical aspect, neglecting the connections involve in a multidisciplinary and interconnected workforce (Klein, 2015; Malcom et al., 2016; Arana-Arexolaleiba et al., 2017). The principles of engineering are crucial as it will reconstruct engineering domain in applying expertise and tutelage leading to accomplishment in building excellence and relevance in EE (ASEE, 2016; Howard, 2018). EE fundamentally has to inculcate critical thinking, teamwork and unique means in solving engineering problems in the society. More so, the serious call for engineering curriculum to be revised along with coursework, revealing opportunities that will integrate application of skills to social issues to improve excellence and relevance in EE in 21st century Africa (Klein, 2015; Arana-Arexolaleiba et al., 2017).

This paper presents a systematic review methodology which explore excellence and relevance in EE in 21st century Africa. The systematic review method adopted in this paper identifies and appraise published articles from year 2015 to 2020 in the fields of Engineering, Education and Sociology systematically. The purpose of this approach is to appraise published reviews on excellence and relevance in EE in the 21st century Africa, and to discuss its implications for recommendations. The main objective of this paper is to fill the research gap by contributing to the overall understanding of excellence and relevance in EE

in 21st century Africa. Specifically, we explore how excellence and relevance can shape EE; and to investigate the role excellence and relevance in EE can play in shaping 21st century; as well as its implications for EE in the 21st century Africa, hence, recommendations were advocated.

## METHODOLOGICAL APPROACH

Systematic literature review was conducted as recommended by Booth et al. (2016) and Gough et al. (2017) where the authors derived formulated review questions, identified relevant studies, selected studies that fit the inclusion criteria, and evaluated the quality of the research studies, as well as summarized the evidence by use of an unambiguous methodology. Based on the study research questions, relevant studies have been identified through reviewed articles archive. The descriptors "excellence in EE", "relevance in EE", "excellence in EE in 21st century Africa", and relevance in EE in 21st century" were used to locate key bases. These descriptors were also used in permutation with other descriptors such as "Africa", "global", "21st century", "developed countries", "developing countries" and "Africa" as these are all under-represented factors in EE (Borrego et al., 2015).

Several papers (Borrego et al. 2014; Borrego et al., 2015; Inês Doreito et al., 2019) were identified as prospective sources of information, however, quality articles who met the following inclusion criteria were reviewed: (1) Published between 2015 and 2020; (2) enumerated excellence in EE in 21st century Africa as one of the lenses for analysis; and (3) examined relevance of EE in 21st century Africa. Again, the papers were allocated into sub-sections relating to study objectives and identified types of analytical themes in sampled articles were itemized. In total, there were 39 reviewed articles indicating systematic review articles. Of those 39 articles, only 30 articles clearly that were identified with the theme 'excellence and relevance in EE in 21st century Africa' were used. The other nine articles simply specified more of 'analytical hypothetical papers'.

To recap the validation found in these sampled articles, appraisal of the sampled articles was completed, along with a developed coding sheet. These identified grouping on the coding sheet involve study's objectives, research questions, methods, type of data collected, study population, and relevant findings. Also, methods used to evaluate and review published articles scientifically, were drawn from existing studies (Booth et al., 2016; Gough et al., 2017; Torres-Carrion et al., 2018; Inês Doreito et al., 2019). This was followed by adopting logical research practices and reporting of systematic reviews were explained explicitly. After review, the principal investigator synthesized the preliminary findings and patterns recorded in summaries. The author reviewed these summaries and preliminary findings to guide the final review.

After the articles were analysed, the principal investigator developed a typical sampling framework in which the articles were used to outlined the research questions. These illustrative samples were not taken verbatim, but rather synthesized to illustrate how analytical research in EE can reframe to redefine key themes and research questions in excellence and relevance in EE, as indicated by Inês Doreito (2019) and Brown et al. (2015). In addition, identifying and appraising process of published reviews allows researchers to describe the quality of compiled existing studies, summarize and compare the conclusions of the reviews as well as discussing the implications and recommendations of the reviews (Booth et al., 2016; Gough et al., 2017). The principles of systematic review methodology were emphasized in the studies to describe how excellence and relevance in EE in the 21st century are primarily enacted (Gough et al., 2017; Torres-Carrion et al., 2018; Inês Doreito et al., 2019). In the discussion section, we illustrated how we outlined representative research questions presented in the reviews highlighted by the studies analysed.

## LIMITATIONS

While this study focused on published articles in relation to excellence and relevance in EE in 21st century Africa, it is possible that the authors may have omitted important studies that may have included excellence and relevance in social and educational engineering areas of research. Furthermore, it is documented that by selecting publications from 2015 to 2020, the principal investigator may have omitted earlier studies that have discuss excellence and relevance in EE in the 21st century Africa. However, the focus of this work was to explore the state-of-the-art of these types of studies on excellence and relevance in EE. Finally, we want to acknowledge that some of the studies reviewed used more than one rational theoretical framework. However, within our inclusion criteria, we focused on studies that used at least one logical context and did not analyse the impact of those that may have used a combination of these outlines.

## OVERALL LITERATURE REVIEW

In 21st century Africa, EE is contemplated as a significant economic development driver in developed and developing countries. Engineering workforce is critical, as countries are undergoing modernization and globalization with challenges of economic uncertainties (OECD, 2015a; 2015b; Wankat et al., 2016). Engineers are made to determine nation's economy in order to provide for her citizens to improve quality of life among citizens (Ryland, 2016). Significantly, engineering workforce requires stakeholders to engage in an in-depth mechanisms needed in understanding the differentials in stimulating excellence and relevance in EE in 21st century Africa (Fenelli et al., 2016).

Conversely, excellence and relevance in EE has become a subject of recent debate in 21st century for African engineering institutions, as such importance has been recognized in traditional EE. While EE are supposed to be at the lead in conceiving excellence and relevance in engineering field, yet EE still lag behind in implementing recommendations from policy makers (Garcia Martin et al., 2017). The main reason for advocating for excellence and relevance in EE in Africa suggested a growing research methods that will successfully build generations of 21st century engineers. The EE focus needs to be extended as a framework to engage students and

professional from diverse areas (Lee, 2016; Besterfield-Sacre et al., 2019).

Quality education should be placed with high values, as it will restructure and reconstruct EE following accreditation in EE (Koretsky et al., 2019). Accreditation process in EE creates quality of EE programmes, identified with quality standards to meet needs of engineering profession. For instance, The Accreditation Board for Engineering and Technology (ABET) accreditation in EE provides standards for engineering profession, from which it prepares students for quality EE programmes (Pan et al., 2018). Therefore, evolutionary changes in engineering projects, has made engineering learning institutions to redesign flexible platforms in seeking continuous improvement in excellence and relevance in EE.

Therefore, evaluating and updating of programmes are critical in excellence and relevance in EE, as a clearer understanding of programme goals and objectives, are identified with established targets (Simmons et al., 2019). Evaluation and approval of engineering programmes through advisory boards displays strong quality in excellence and relevance in EE. ABET is a recognized accreditation body for engineering programmes and its main responsibility is to clearly demonstrate that EE programmes meet the criteria including: continuous developments, institutional funding, and programme standards (NAE, 2004; 2005). As an academic instituted board, they are mainly concerned in provide solutions to complex problems, such as building a knowledge-based economy. Similarly, educators have a fundamental role to play in addressing the skill gaps in EE. Contributing in building excellence and relevance in EE requires restructuring a framework in bringing a dramatic change in EE that will include expertise contributions (Arana-Arexolaleiba et al., 2017).

The need for 'new' engineering teaching skills are important as they involve new teachings in new learning environments where students can work on real-world problems and learning how to create substantial exemplars adopting ethical features (Wankat et al., 2016; Simmons et al., 2019). Professional skills are critical in meant to be integrated in collaboration projects that will facilitate engineering graduates to explore potential engineering trends. Therefore, addressing skill gaps in engineering, required an increasing diversity and attention of engineering educators to build a diverse learning environment, with more practical actions proposed to students. This will aid in assisting high standards in building engineering graduates to demonstrate competency and diligence in valuing excellence and relevance in EE.

**Exploring the Concepts of Excellence and Relevance in Shaping Engineering Education in 21st Century Africa**

Africa's demographic dividend have provided tasks for global and national policy-makers, as EE is yet to make a significant difference in producing engineering graduates as they enter labour force (Thom-otuya et al., 2016). Thus, youth are seen as asset and valuable in economic activities, unlocking the sustainable economic growth in 21st century Africa. Remarkably, the existence of 'youth bulge' representing working population is estimated to grow by 70% by 2035 reaching 450 million people (UNESCO, 2017). Sustaining self-skill development and knowledge among 'youth bulge' population within Africa region have advantages, yet to be fully utilized as millions of youths lack skills to compete in a global economy. Therefore, this is critical for Africa's economy growth (UNESCO, 2016).

Africa's region with the 'youth bulge' population anchored on United Nations' Sustainable Development Goal (SDG) 4 and Education 2030 agenda, have compel countries to equip youths with the basic knowledge and skills that have a long time sustainability in stimulating development and economic expansion (UNESCO, 2016; 2017). Hence, EE in 21st century Africa has been built to structure students in possessing not only profound disciplinary knowledge, but also a range of significant competencies (Koretsky et al., 2019). But engineering institutions are yet to inculcate these recommendations and reforms in EE as it will devalue the quality of pioneering engineering programmes.

Consequently, the pioneering initiatives speak on the EE enhancement of abilities and skills along with expansion of disciplinary knowledge and skills among students. These initiatives are built on teaching techniques, in combination with purpose in making teaching and learning more efficient in EE according to the changing needs of engineering profession. The teaching techniques include: observational learning, assignment-based learning, investigation-based learning and face-to-face teaching (Wankat et al., 2016). Therefore, to thrive in the 21st century's innovation-driven economy, engineering educators are to employ contemporary diversified teaching skills different from the conventional teaching patterns, that will make EE students to be diligent and resourceful (Simmons et al, 2019).

This becomes important as globalization in engineering labour force has brought changes that have heightened modern society needs to scout for 21st century skills (Lima, 2017). Recently, skilled jobs are more centred on solving unstructured technological problems by finding effective solutions to address such concerns (Pan et al., 2018). In high-income countries with high technology usage, most of their manual work force have been gradually been substituted with high technology applications and robots that are imbued into human existence and day-to-day work. Several debates on reconstruction of engineering courses to address skill gaps and competencies are beginning to expand the call for excellence and relevance in EE (Howard, 2018).

Thus, EE can be deployed in developing 21st century skills as they are portfolio of vital solutions to close the skill gaps in EE as well as in the profession (Falck et al., 2016). Also, at the classroom level, educators are expected to make efforts in creating learning objectives and providing appropriate learning outcomes based on students' needs (Klein, 2015). All these efforts must be linked together and aligned with 21st century skills development. EE students needs new skills to become scholarly built for future engineers in 4IR phase, as engineering educators as well as other stakeholders gain benefits from the performances in EE.

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## THE ROLE EXCELLENCE AND RELEVANCE PLAY IN SHAPING 21ST CENTURY IN AFRICA THROUGH EE

Over the past decades, there has been a notable shift in EE as professional and industrial experiences of engineering practitioners are regarded as important to be co-opted in EE to revere the excellence and relevance of EE in 21st century Africa (Malcom et al., 2016). Their potential contributions grounded in practical and relevant engineering experiences, have been debated upon to be brought into engineering institution to champ what engineering career and academics brings to our everyday lives (Ryland, 2016). EE has an important position to play in integrating the role of excellence and relevance in responding to engineering challenges with effectiveness and efficiency as the globalized economies demands in the 21st century (Pan et al., 2018; Simmons et al., 2019).

Understanding the rapid transformation of technology in Africa, the 21st century global economy requires well-trained and culturally-sensitive engineers that will make impact universally. Hence, engineering educators have indicated that with the present mandate and pressure from the 4IR in the 21st century Africa, present approaches in teaching and restructuring engineering learning environments are inadequate in addressing and supporting twenty-first century learning needs and skill development (Besterfield-Sacre et al., 2019). As societies become more knowledge-based, and focus has shifted away from access towards equitable quality education to lifelong learning, this has intensified training and skills for improved learning outcomes in EE (Lee, 2016). Therefore, improving student's learning in among EE undergraduate depends on improved teaching and assessment, involving numerous changes in an adaptive engineering scheme.

Increasing attention should be given to quality of teaching and learning at the university level across EE to demonstrate its excellence and relevance in EE (Koretsky et al., 2019). Accumulative pressure to ensure effective teaching in engineering learning institutions draws an extensive scholarly and professional skill practices at a high level of contextual expertise, by sharing an understanding of what it means to be an effective engineering educator, which forms the basis of quality ensured. Engineering skills and specific roles are in high demand, which are highly prized by industries for financial services. Depending on investment in human capacity, individuals opting for EE have seen the future benefits in graduating with engineering degree (Forster et al., 2017; Howard, 2018; Besterfield-Sacre et al., 2019).

Furthermore, to instil excellence and relevance in EE, sustainability in EE development will help educators to tutor students and motivate them in participating in building a viable society through engineering platforms (Brown et al., 2015; Felder et al., 2016). EE must employ different strategies to integrate excellence and relevance in sustaining formal curriculum, innovative learning strategies, and establishing new partnerships with external individuals (Lima, 2017; Howard, 2018). This calls for innovative learning in developing and transferring knowledge skills and competencies in incorporating excellence and relevance in EE in the 21st century Africa.

## THEORETICAL FRAMEWORK

This paper was guided by Social Constructivism Theory (SCL) propounded by Lev Vygotsky (1978). The theory posited that social context of learning can possibly be separated, as human development is socially placed and knowledge is built through communication. This theory can be applied to how individuals can structure the ways in revitalizing excellence and relevance in EE in the 21st century Africa. Vygotsky (1978) assumed that society has a role to play in the process of constructing meaning within the environment an individual grows up and how it will influence how and what they think. Thus, every part of teaching and learning is a substance of input and conveying socially instituted knowledge.

As, engineering institutions are meant to teach technical aspects of engineering, requires students' motivation to participate in a mix of classroom participation in practical assignments in preparing students in a full range of excellence and relevance in EE in the 21st century (McKinley, 2015; Falck et al. 2016). This will help to reshape teaching and learning practices in re-establishing excellence and relevance of EE to create strong values with a broad perspective of better ability in producing quality solutions that will address real-world problems. Notably, EE goes beyond classroom theoretical teaching, rather than to focus on developing abstracted areas involving skills development (Pan et al., 2018; Simmons et al., 2019), that will enable EE students in applying knowledge learnt to real life situations and adapting to engineering workforce settings.

Social constructivism theory has implications for teaching and learning, which is often determined by incorporating the roles involved in specified culture of development of human ability and skills development (McKinley, 2015). Moreover, the theoretical idea is centred on how human learning is constructed, and in what way learners build new knowledge upon previous learning. This previous knowledge can influence modified knowledge an individual has constructed from learning new experiences. This is to imply that learning becomes an active process in constructing meaning through active engagement with the world. Dewey (1938) and Oliver (2000) have shown that learning as a social activity inspire individuals to interact with each other rather than engaging in a theoretical idea.

Also, cognitive development stems from social interactions from guided learning within the zone of proximal development with co-constructed knowledge. This aspect of learning becomes a collaborative process in which knowledge develops from individuals' interactions within society and culture (McKinley, 2015; Makio-Marusik, 2017). Therefore, engineering universities must have an ideal space for scholarly network in searching for new ideas in order to reinstate excellence and relevance in EE. This becomes an imperative as it becomes a top advocacy policy issue in optimizing methods in developing relevant teaching of 21st century skills in rebuilding excellence and relevance in EE in the 21st century Africa.

## DISCUSSION

Excellence and relevance in EE is an important development, attracting a lot of attention from academia and professional in the 21st century Africa. Recently, EE has reinvented itself in preparing students by employing new methods of integrating expertise from within or outside engineering units (Lee, 2016; Arana-Arexolaleiba et al., 2017). To achieve this, requires a strategic assessment to encourage the growth and development of new techniques in supporting new career opportunities in EE. This will help to aligned engineering learning facilities with teaching philosophies and students' capacity for a rewarding teaching (Felder et al., 2016). Importantly, future engineer has an important role to play in grand challenges facing technology in the 21st century (Besterfield-Sacre et al., 2019). Future engineers need extra skills and knowledge that will aid them in interdisciplinary collaboration and teamwork in defining and applying critical thinking and increasing literacy attributed with 21st century skills.

Hence, to address skill gaps in EE, is to ensure that engineering students should exhibit a strong working knowledge that has a broader perspective in engineering. This requires emphasis to be shifted from teaching to learning from different angles of acquiring knowledge in EE (Lee, 2016; Makio-Marusik, 2017; Lima, 2017). The 21st century future engineer requires diverse skills in creative thinking and collaborating in multidisciplinary teams. Thus, one of the most significant challenge in African universities is lack of investment in human capacity to enhance potentials among future graduate students (Garcia Martin et al., 2017; Besterfield-Sacre et al., 2019). Such human investments and capacity building provides scientific and technical knowledge in diversifying engineering profession. EE possesses abilities in learning and research, that capitalize on reforming engineering and creating inventions that will lead to transformation of EE (Elrod et al., 2017; Pan et al., 2018).

However, 21st century era has brought about exponential growth evident with a rapid rate as new technologies were spawned from EE curriculum at the global level. Through a consistent and systematic approach in addressing curriculum modification, monitoring and evaluation of engineering programmes is key in bringing changes in EE programmes (Finelli et al., 2016; Pan et al., 2018). This approach entails a progressive plan built around EE vision and mission of the university that will facilitate monitoring and enable continuous improvement in training students to attain a high level of competence in engineering profession (Malcom et al., 2016; Elrod et al., 2017). Designing and revising EE curriculum may divulge in an approach that include standard teaching and programme content for engineering students. EE curriculum should be revised according to considerations from advisory board in terms of evaluation of programme and reviewing of existing courses (Godwin et al., 2016; Makio-Marusik, 2017).

Also, through staff education and training, comprehensive teaching and learning environment can be created through sensitization and awareness programmes organized among engineering educators. While the demand for contemporary engineering knowledge is attracting restructuring of research practices, modern EE are designed to have production capacity in building EE students for 21st century demands (Andrews et al, 2016; Leicht-Scholten et al., 2016). Engineering development is strongly connected to productivity and sustainability of EE excellence and its relevance in this epoch. New engineering courses are designed to suit 21st century skills, offering better opportunities via EE networks through scientific contributions in accredited journals (Mitchell et al., 2015; Wilson-Medhurst, 2016).

Engineering educators and professionals are required to keep up-to-date with insights gathered from classroom experiences. Effective research practices are encouraged in EE to evaluate improvement of staff development capacity (Koretsky et al., 2019). This can be established with high expectations from faculty member through providing feedback from their experiences gained over time. Incorporating interdisciplinary research studies will draw ideas from different disciplines, that will make a lot of differences in contemporary research frameworks in EE. Combination of teaching and research involving variety of methods will initiate some positive consultations that will enhance a growing student population (Sun, 2015; Garcia Martin et al., 2017).

## CONCLUSION AND RECOMMENDATIONS

This paper attempts to show that in the 21st century Africa, EE has a cutting-edge in the global view, with a strategic impact in rebuilding excellence and relevance engineering. Besides, the idea in bracing EE for its excellence and relevance is crucial in achieving new SDGs targets allied with engineering impacts, stimulating engineering advancement in the 21st century Africa. Highlighting importance to research-based engineering programmes and curriculum built from academic and professionals' contributions from their citadel of knowledge will support 21st century skills and knowledge built in engineering students to prepare them as the 21st century engineers. As they will posses the needed skills to tackle engineering problems by offering solutions to address engineering challenges by hounding advancement of the nation's economy and the quality of life of citizens.

Furthermore, the focus of EE should centre on graduate students' productivity outside the university, by facilitating internship programmes in engineering industries, facilitating intellectual potentials and skill development among undergraduate and graduate engineering students. Also, engineering accreditation and advisory boards should be instituted to provide institutional funding and support to various engineering institutions to rebuild engineering education for its excellence and relevance in 21st century Africa. This will go a long way to positively influence engineering students to reposition and develop themselves with the right skills and capacity to meet the 21st century demands of engineering industries as this will announce its excellence and relevance in EE in Africa. Therefore, key recommendations are advocated as follows:

1. To achieve excellence and relevance in EE, requires engineering educators and professionals to encourage and accept students' autonomy and initiatives that will allow them to respond and drive lessons that will shift instructional strategies in positive dialogue between

teacher and student. This will aid in nurturing students' natural curiosity through frequent use of the learning cycle model.

2. Emphasis on engineering revised curriculum and redesign of courses should be mapped at institutional level which will frame a curriculum vision showing excellence and relevance in EE equipped with 21st century skills for the future education of engineering beginners.
3. Great changes in engineering roles and profiles should be identified as a framework that can be developed to guide symposiums sessions of multidisciplinary research project centred on engineering roles as a guiding principle to revive excellence and relevance in engineering education.
4. A nation's engineering capacity is dependent on government's commitment to EE in producing excellence and its relevance in the 21st century Africa. This commitment could be seen in areas of supporting and investing in engineering institutions to engage in collaboration research between academia and industries in stimulating nation's growth and economic development.
5. Appraisal of excellence and relevance in EE is absolutely crucial and future engineers need to be aware that they are working in a competitive environment in which there is a fine balance between quality and value as well as important concerns have been made. Scholarships and competitive programmes can be instituted to motivate engineering undergraduates and graduate students to put in their best in various engineering endeavours.

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