FRAMEWORK FOR TRANSFORMATION DEVELOPMENT OF SUDAN UNDERGRADUATE ENGINEERING EDUCATION PROGRAM

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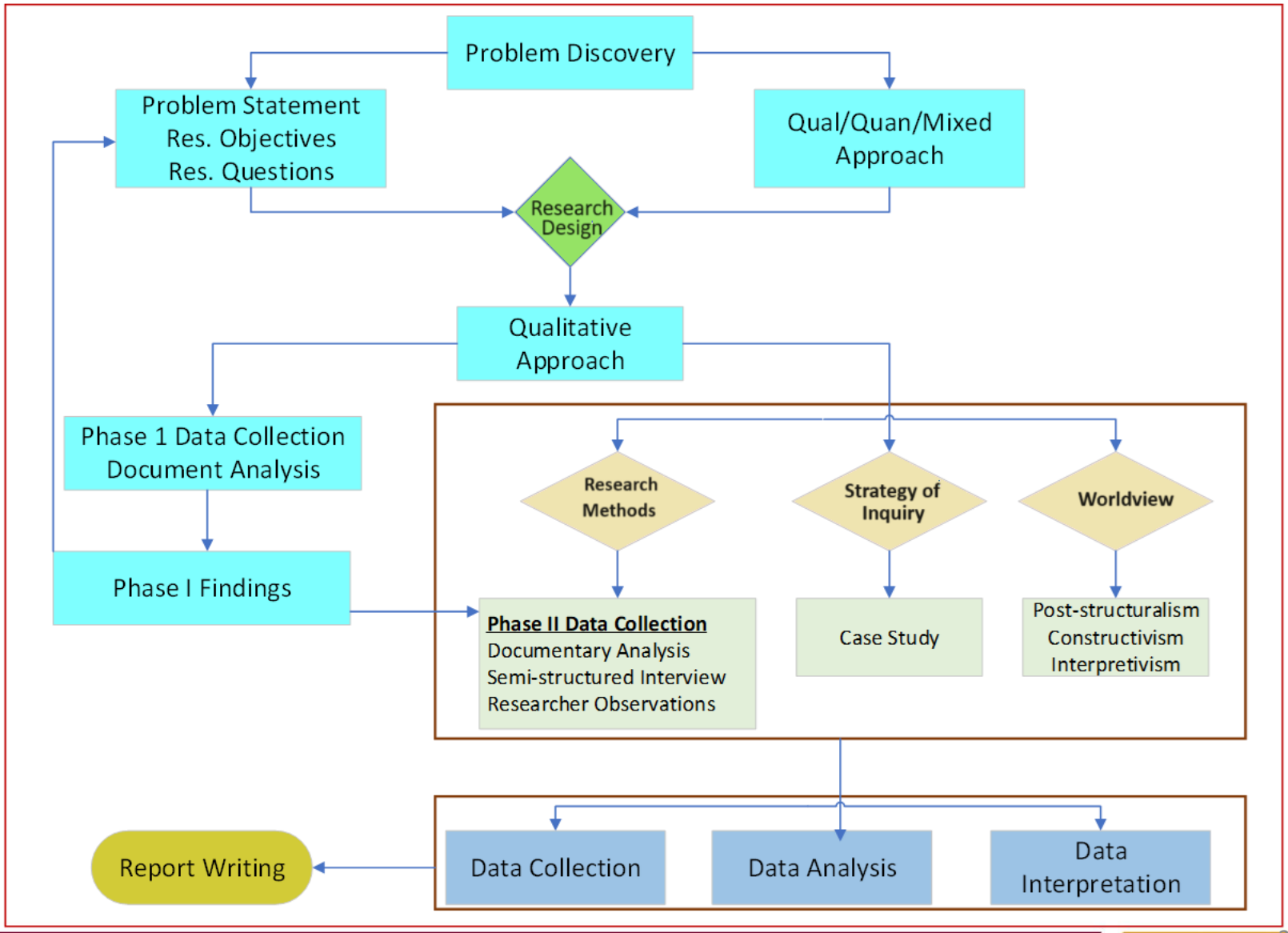
FLOW OF THE PRESENTATION

- CHAPTER 1: Introduction
- CHAPTER 2: Literature Review
- CHAPTER 3: Methodology
- CHAPTER 4: Findings of the Study
- CHAPTER 5: Discussion of the Findings
- CHAPTER 6: EE Transformation Framework
- CHAPTER 7: Conclusion and Recommendations

Study Overall Flowchart



CHAPTER 1:

INTRODUCTION

Problem Discovery

STATEMENT OF THE PROBLEM

The **inability of EE to graduate enough number of qualified engineers**:

1. The problem of **inappropriate curriculum**.
2. The problem of **incapable engineering educators**.
3. The problem associated with **Traditional T&L philosophy**.
4. **Lack of an appropriate framework** to resolve the Sudanese engineering education issues.

(UNESCO, 2019; Osman, 2014; Mohamedbhai, 2014; ; Idris, 2012; Gasim, 2010).

Problem Discovery (Cont.)

RESEARCH OBJECTIVES

1. To investigate **the current situation of the engineering curriculum**.
2. To investigate **the situation of engineering educators** in terms of qualification and professional development.
3. To investigate **adopted teaching and learning philosophy** by engineering programs.
4. **To construct a transformational framework** for the Sudanese engineering education programs.

Problem Discovery (Cont.)

RESEARCH QUESTIONS

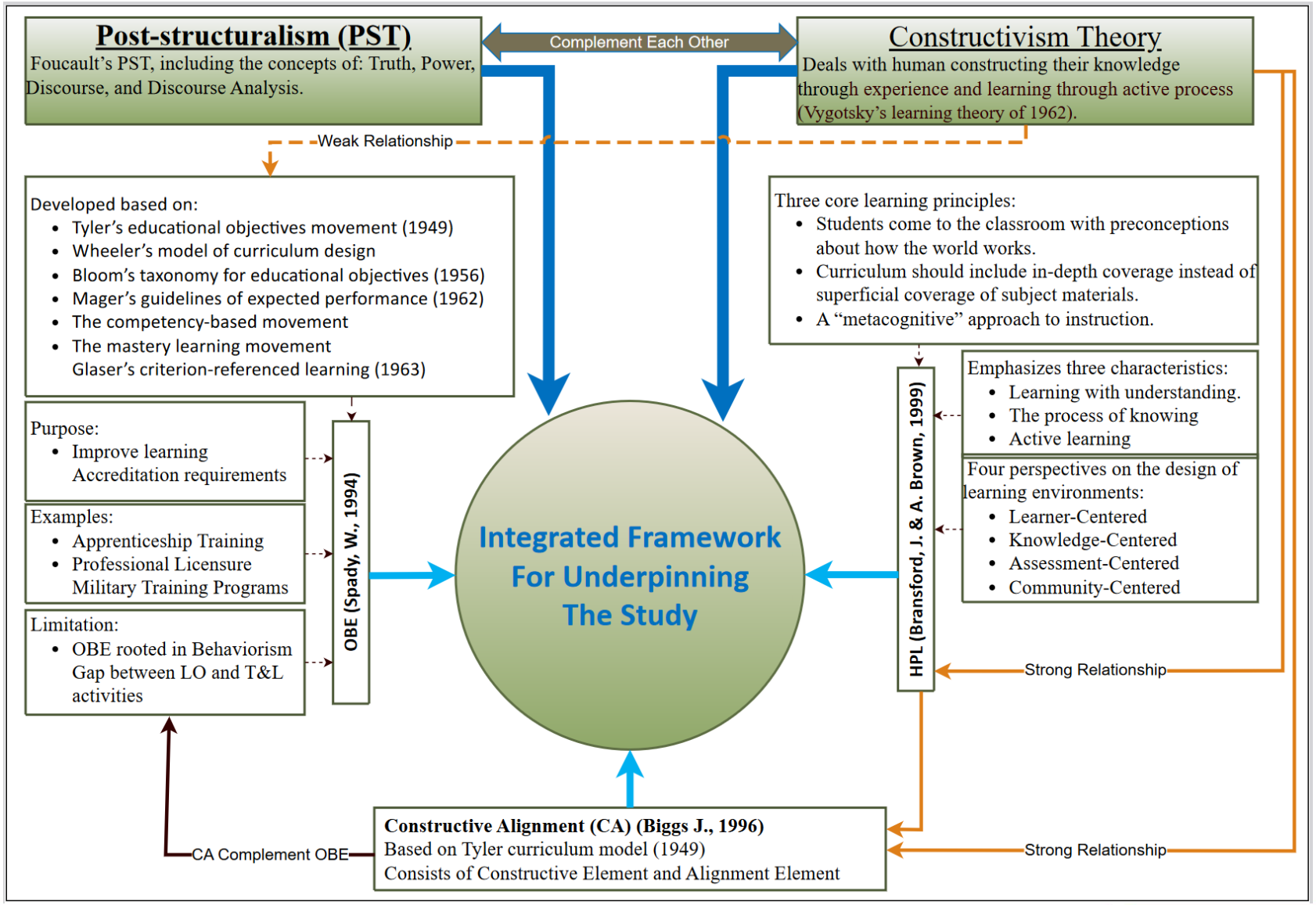
1. **What is the current situation of engineering curricula** in Sudan?
2. **What is the situation of engineering educators** in Sudan regarding their teaching effectiveness, qualification, and professional development?
3. **What are the current teaching and learning approaches** adopted by the Sudanese engineering education programs?
4. **Why is there a need for a framework** to transform the Sudanese engineering education programs?

Research Gap

The literature review led the researcher to establish:

- The **Engineering Education Research (EER) Gap**:
  - The **Global** EER (Section 2.2).
  - The **Sudanese EER** (Section 1.1.3).
- **The need for a framework to guide the investigation** and evaluation of the Sudanese engineering education system.

Theoretical Perspectives Framework



To put the IFW to work, the researcher has done two things:

- Identified the Context for the EE Field.
- Constructed a Conceptual Framework.

First: The Context for EE Field

Burton Clark (1983) Model:

Elements of the Broader T&L Environment (as part of an academic system)

i) **Discipline-centered** (Sudanese EE programs)

ii) **The enterprise** (UofK as a case study), and

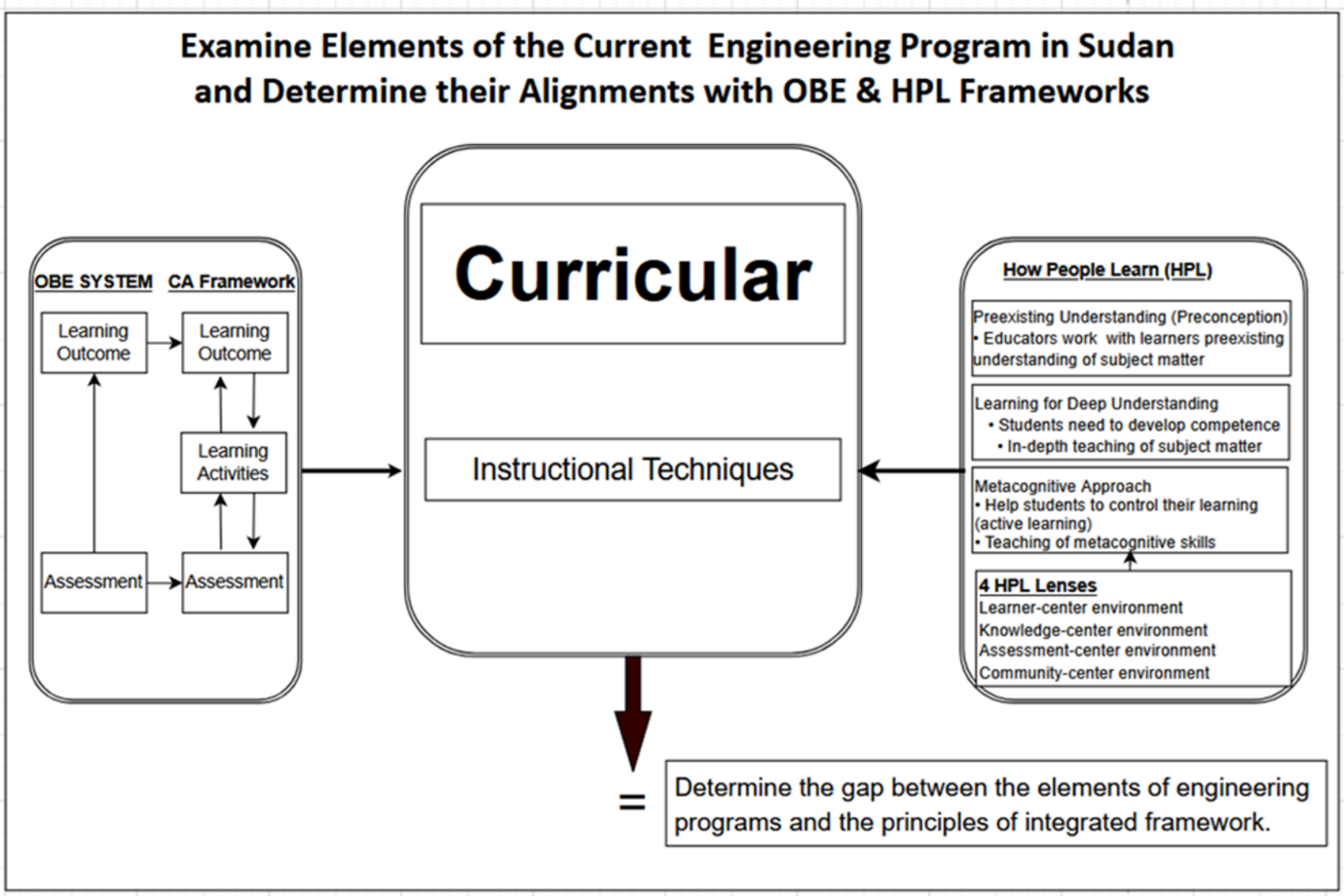
iii) **The organization and inter-institutional links** (List all stakeholders).

(Brennan, 2010 p234)

- **Post-structuralism:** To identify the "Interconnected Power Network" among stakeholders within the discursive field

Stakeholders	Rights & Privileges	Duties & Responsibilities
Stakeholders within the Discursive EE Field	Power as manifested/exercised by each stakeholder Others expected comply with	Responsibilities of each stakeholder towards other stakeholders

Second: Conceptual Framework



CHAPTER 2:

LITERATURE REVIEW

Literature Review

Chapter 2 consists of six sections:

2.1 Background of the Study	2.1.1 Sudan Profile	2.1.2 Engineering & Engineering Education	2.1.3 Education in Sudan	2.1.4 Engineering Education in Sudan	1.1.3 EER in Sudan
2.2 Global EE Research (EER)	2.2. 1 Overview of EER	2.2.2 EE as Part of STEM Research	2.2.3 EE as Standalone Research	2.2.3.1 EER-Using Discourse Analysis	2.2.3.2 EER Additional Frameworks Models
2.3 Learning Theories (LT)	2.3.1 Classification of learning theories: 1. Cognitive LT; 2. Behaviorism LT; 3. Humanism LT 4. Connectivism LT; 5. Kolb's Experiential LT (KEL)				2.3.1.5 The Constructivism Theory
2.4 Theoretical Perspectives (PST)	2.4.1 An Overview of PST		2.4.2 A Brief of Foucault Contribution and Concepts		
2.5 Theoretical Perspectives & Frameworks	2.5.1 Outcome Based Education (OBE)	2.5.2 Constructive Alignment (CA)	2.5.3 How People Learn (HPL)		
2.6 Taxonomy of Educational Objectives					

Research Background (Cont.)

Sudan Background

Sudan location

The global sustainable competitiveness index
Source: Sudan GSCI_2020

Indicator	Sudan		Global	
	Rank out of 180 Countries	Score	Average	Best
Natural Capital *	78	49.3	46.7	72.8
Sustainable Competitiveness	163	39	45.6	
Intellectual Capital	145	25.7	41.2	74.8

* Land, water, oil, minerals, livestock, agricluture, ... Etc.

Sudan Location (in Green) within Map of Africa

http://thehelpfulgarden.blogspot.com/2012/08/great-place-for-control- maps.html

Research Background (Cont.)

Sudan Background (Cont.)

Engineering Education Situation

- Engineering education in Sudan started 1939.
- The next table compares engineering institutions to the tertiary education, as of 2018.
- Engineering capacity is very poor.
- Sudan is never been included in Engineering Index (EI) developed by Royal Engineering Academy (RAE).
- Sudan is behind in all engineering indicators that make the EI by RAE

Higher Academic Institutions

Indicators	2018
Number of academic institutions	132
Institutions with Eng Programs	62
Total students	680,696
Engineering students	61,638
% of engineering enrolment	9.1%
Total graduates	123,887
Engineering graduates	10,047
% of engineering graduates	8.1%

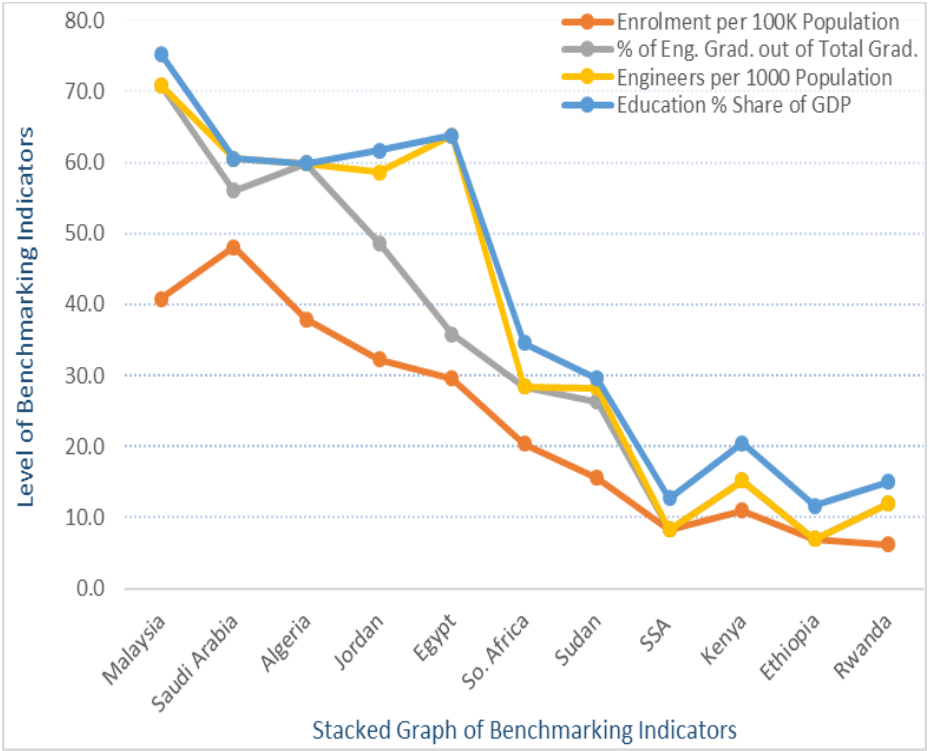
Source: Ministry of Higher Education and Scientific Research (2017-18 Census Data)

Lack Enough Number of Qualified Engineers

Research Background (Cont.)

EE in Sudan versus Benchmarking Countries (UNESCO, 2018)

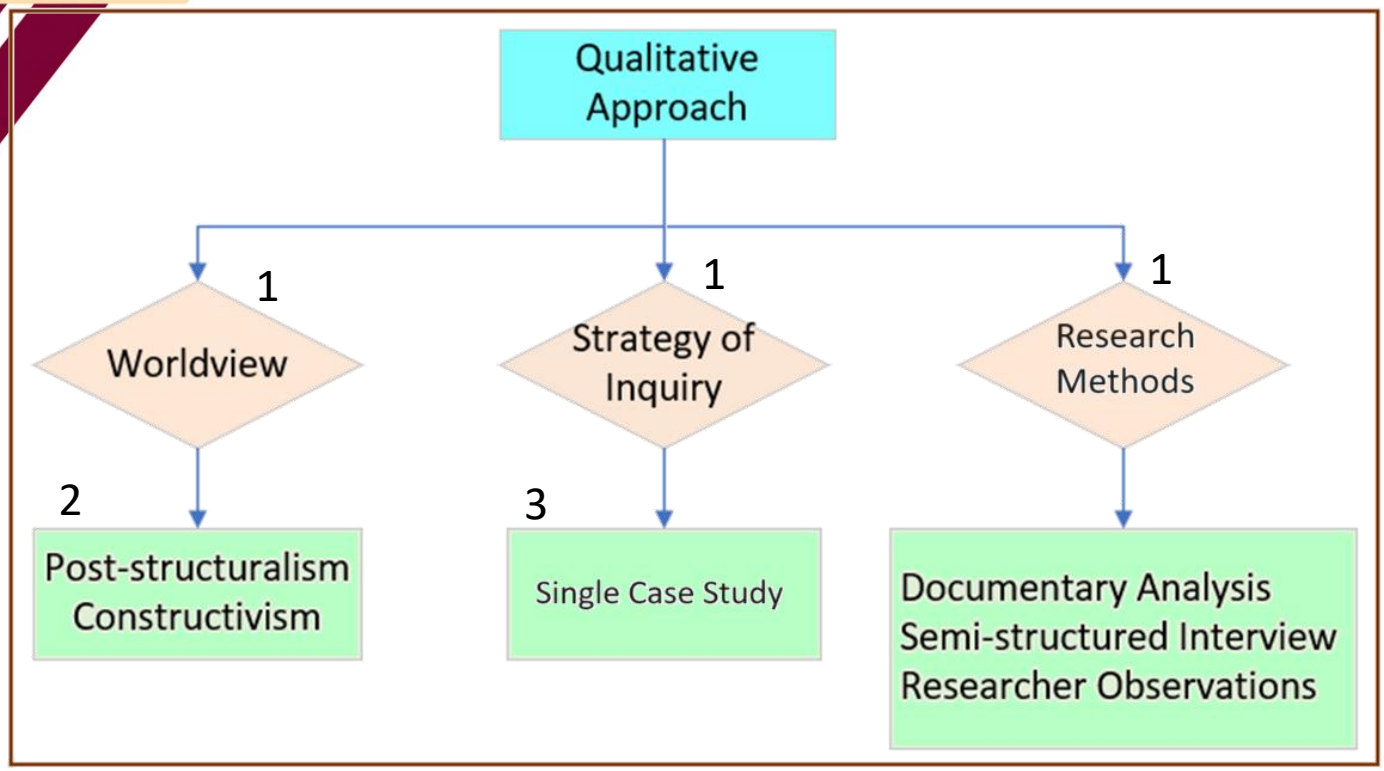
Benchmark Countries	Benchmarking Indicators (2018)			
	Enrolment per 100K Population	% of Eng. Grad. out of Total Grad.	Engineers per 1000 Population	Education % Share of GDP
Malaysia	40.8	30.1	..	4.5
Saudi Arabia	48.1	7.9	4.6	..
Algeria	37.9	22.0	..	..
Jordan	32.2	16.4	10.0	3.0
Egypt	29.6	6.2	28.0	..
So. Africa	20.4	8.0	..	6.2
Sudan	15.6	10.7	1.9	1.4
SSA	8.3	..	..	4.5
Kenya	11.0	4.2	..	5.3
Ethiopia	6.9	..	..	4.7
Rwanda	6.2	5.8	..	3.1



CHAPTER 3:

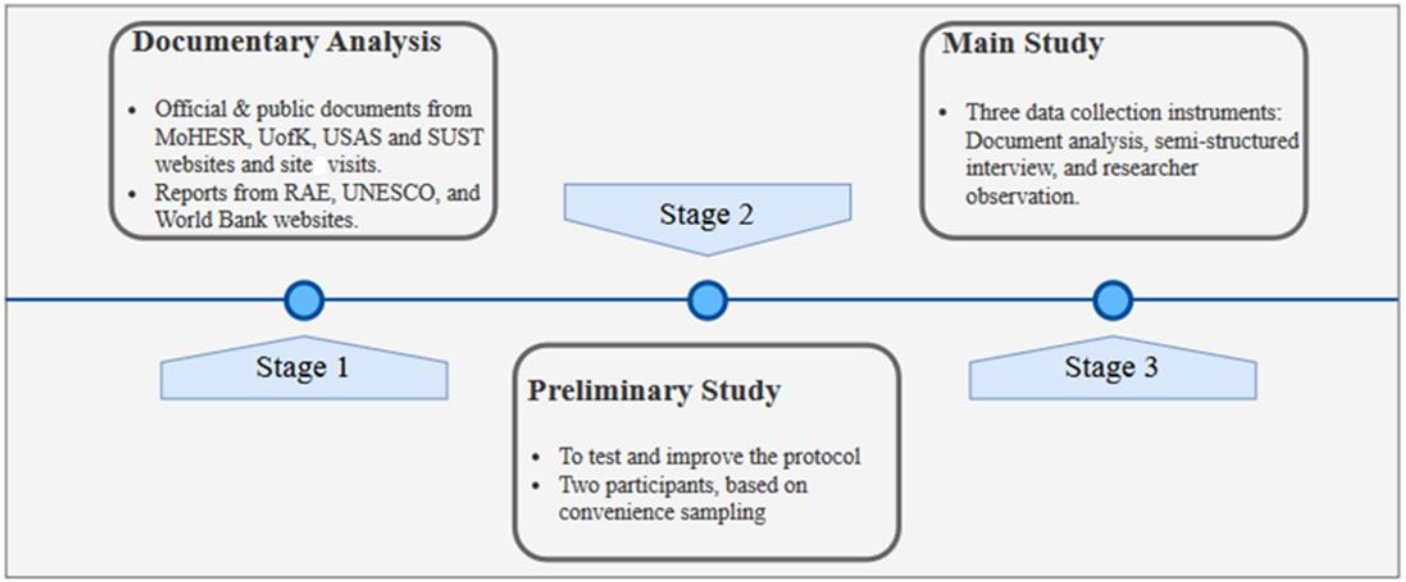
METHODOLOGY

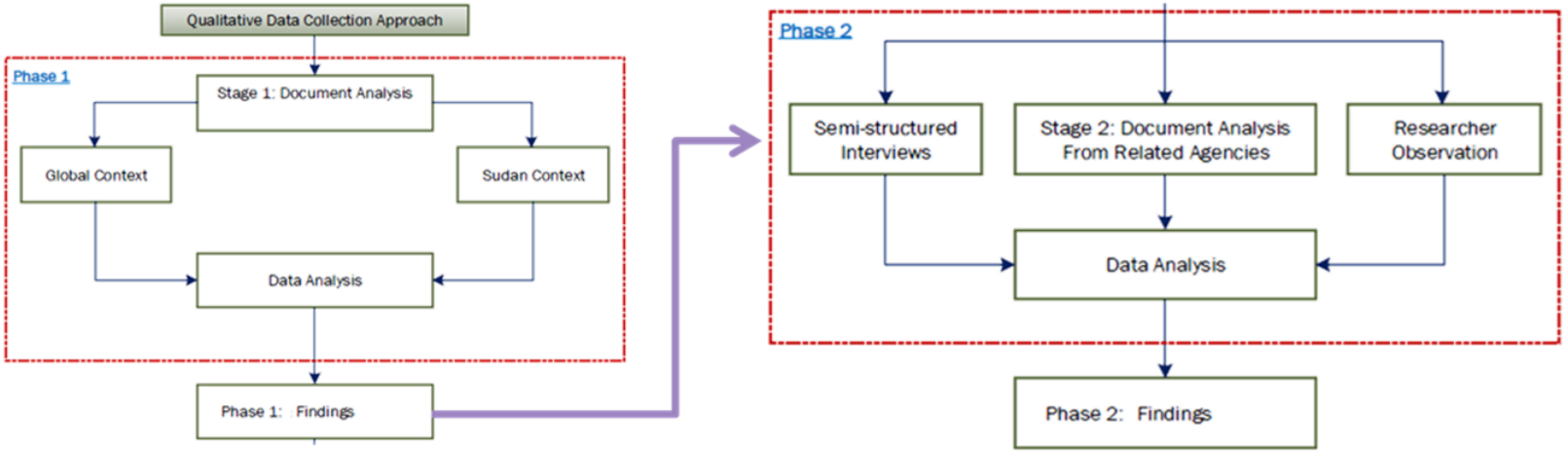
Research Design



1. The research design has 3 interrelated components (Creswell, 2009).
2. PST & constructivism are used to construct an IFW for underpinning the study (Slide 9).
3. Single case study (S. Merriam, 1998 and R. Stake, 1995).

Three Distinctive Stages of Data Collection





Phase 2 Data Collection

Research Objectives To investigate:	Research Questions	Data Sources* and Collection Methods
1. the current situation of the engineering curricular.	1. What is the current situation of engineering curricula in Sudan?	• Semi-structured interviews • Document No.: 1, 4, 6, 8, 11, 13, 17, 21, 22, 25, 26 and 27 (from Table 4.1) • Observation No. 5a (from Table 4.4)
2. the situation of engineering educators in terms of qualification and professional development.	2. What is the situation of engineering educators in Sudan with regards to their teaching effectiveness, qualification, and professional development?	• Semi-structured interviews • Document No.: 1, 4, 5, 6, 8, 11, 17, 22 and 27 (from Table 4.1) • Observation No. 5b (from Table 4.4)
3. adopted teaching and learning philosophy by engineering programs.	3. What are the current teaching and learning approaches adopted by the Sudanese engineering education programs?	• Semi-structured interviews • Document No.: 1, 4, 8, 11, 25, 26, and 27 (from Table 4.1) • Observation No. 5c (from Table 4.4)
4. To construct a transformational framework for the Sudanese engineering education programs.	4. Why is there a need for a new framework to transform the Sudanese engineering education programs?	• Semi-structured interviews • Document No.: 5, 8, 10, 17, 22, 23 and 27 (from Table 4.1) • Observation No. 5a and 6 (from Table 4.4)

* Phase II data sources: UofK and MoHESR & SEC as related to UofK

CHAPTER 4&5: FINDINGS & DISCUSSION

4.1: Data Collection

4.2: Process of Data Analysis

4.3 & 5: Findings & Discussion of the Findings

- **Summary of the Interview Findings**
- **Detailed Findings**
- **Discussion of the Findings**

Semi-structured Interview

- Prepared semi-structured interview guide.
- Conducted a preliminary study to improve the protocol (2 participants).
- Prepared a research information sheet.
- Identified and interviewed 7 participants (60-90 minutes):
  - Started with introduction.
  - Provided the research info sheet.
  - Got permission for audio-taping.
  - Signed a consent form.
  - Questioning:
    - Used the interview protocol as a guide.
    - Began with simple and direct questions.
    - Followed by complex open-ended questions.
    - Moved to probe questions/follow-up.
    - Continued with clarification questions.
    - Concluded the interview.

Preliminary Study

Participant	Gender	Affiliation	Experience
Int1	Male	UofK	Academia 25+ yrs.
Int2	Female	MoHESR	Administration & Academia 10+ yrs.

Main Study

Participant	Gender	Affiliation	Experience
Int3	Male	MoHESR	Administration & Academia 10+ yrs
Int4	Female	UofK	Academia 5+ yrs
Int5	Male	Industry	Industry & Academia 30+ yrs
Int6	Male	Industry	Industry 30+ yrs
Int7	Female	UofK/MoHESR	Administration & Academia 30+ yrs
Int8	Female	MoHESR	Administration & Academia 10+ yrs
Int9	Male	SEC & USAS	Academia 25+ yrs

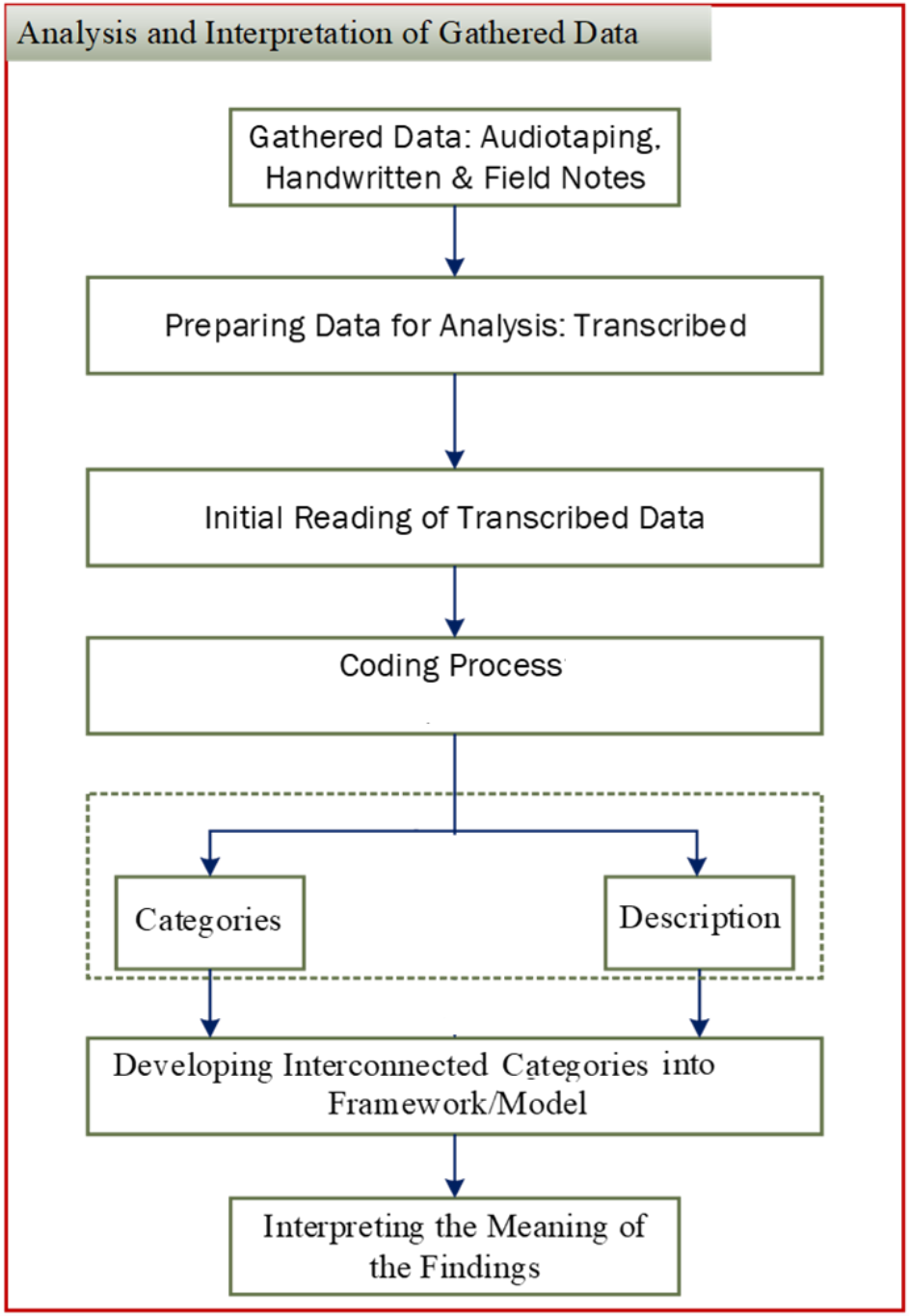
List of Obtained Documents & Their Sources

Phase	No.	Document	Source
Phase I	1	Strategic Plan of Higher Education & Scientific Research 2021-2025.	MoHESR
	2	Report about Non-governmental Higher Education Institutes, 2020.	MoHESR
	3	Performance Evaluation Report, during the period 2019-2020.	MoHESR
	4	Exemplary Engineering College Document, 2011.	MoHESR
	5	Reform of Higher Education and Scientific Research in Sudan-Policies, June 2020.	MoHESR
	6	Reports on Evaluation of Engineering Programs.	MoHESR
	7	Studies Report on Independent Track of Technical Education.	MoHESR
	8	Report on the Urgent Needs of Engineering Colleges at Public Universities.	MoHESR
	9	Admission Guide into Higher Education Institutions, Sudan (Daleel Algobool, 2022-23)	mohe.gov.sd
	10	Ministry of Higher Education and Scientific Research Census Data, 1984-2018	mohe.gov.sd
	11	Sudanese Engineering Council Documents (Laws, Bylaws, Policies, etc.)	SEC
	12	UNESCO 6th African Engineering Week and 4th African Engineering Conference Proceedings, 2019.	UNESCO
	13	Framework for the Implementation of Education for Sustainable Development (ESD), 2019.	UNESCO
	14	Sudan Education Policy Review, Paving the road to 2030, 2018.	UNESCO
	15	Benchmarking Institutions of Applied Sciences, Engineering and Technology (ASET) in Sub-Saharan Africa, 2016.	UNESCO
	16	UNESCO Report in Sudan in 2016–17.	UNESCO
	17	Engineering: Issues Challenges and Opportunities for Development, 2010.	UNESCO
	18	Improving Higher Education Performance in Kenya: Policy Report, 2021.	UNESCO
	19	Sudan United Nations Development Assistance Framework (UNDAF), 2018-2021.	UNESCO
	20	The Human Capital Project, 2018.	WB
	21	Sub-Saharan African Science, Technology, Engineering & Mathematics Research, 2016.	WB
	22	The Status of the Education Sector in Sudan, African Human Development Series, 2012.	WB
	23	Sudan's Infrastructure: A Continental Perspective, 2011.	WB
	24	Assessing Engineering Education, Sub-Saharan Africa- African Technical Series, 1993.	WB
Phase II	25	Aldaleel (2012)- The catalog of the engineering college.	UofK
	26	Engineering program structures and syllabuses of the courses	
	27	Accreditation Criteria of Engineering Programs in Sudan (SEC).	

Main Observations- Details and Required Actions

Main Observations	
No.	Details & Required Actions
1	• Details: Two Participants were unwilling to provide enough information. • Action: Cancelled Participants
2	• Details: One participant gave inconsistent answers to many questions. • Action: Cancelled the interview
3	• Details: Two incomplete interviews because participants had to leave for unplanned events. • Action: Complete the interview using the Zoom Conference meeting
4	• Details: One participant had been engaged in other duties during the interview. • Action: Rescheduled the interview and changed the venue.
5 a-d	• All participants: a) agreed on the outdated curriculum with a lot of theoretical components and irrelevant engineering materials. b) confirmed the need for a hiring structure including competitive working conditions for academic & non-academic staff. c) asked for advanced T&L methods. d) called for a desperate need for improvement of the engineering system in the country.
6	• Details: Observations about lecture halls, chemical and computer labs, and workshops. • Action: Confirmed participants' perspectives about the limited capacity to admit more engineering students.
7	• Details: Some of the challenges are the language barrier, completeness of the interview, and interview distraction. • Action: Conducted interviews in Arabic; completed interviews through Zoom meeting; and rescheduled/ cancelled interviews due to distractions.

Process of Analysis & Interpretation of Gathered Data



(Bryman, 2012; Merriam, 1998; Creswell, 2007)

Coding Process

Systematic Coding Steps (Creswell, 2009):

- Open Coding: These involve generating categories of information.
- Axial Coding: Selecting one of the categories and positioning it within a theoretical model.
- Selective Coding: Then explicating a story from the interconnection of these categories.

Multiple Levels of Coding (Creswell, 2009):

- Initial (broad) coding: 4 pre-defined categories, 5 data-driven categories, and 85 sub-categories.
- Second coding: Similar codes were regrouped under appropriate themes; resulting in 9 categories and 39 sub-categories.
- Third & Fourth Coding: Generated categories and descriptions for analysis and identified how they are linked together.

Cod	Category
Pre-defined coding	1. Curriculum Res. Obj1, Res. Q1
	2. Engineering educators Res. Obj2, Res. Q2
	3. T&L Methods Res. Obj3, Res. Q3
	9. Framework Res. Obj4, Res. Q4
Data-driven coding	4. Engineering graduates
	5. Admission of Eng. Students
	6. Relationship with industry
	7. Collaborations
	8. Accreditation

Category 1: The problem of inappropriate curriculum

Res. Obj1/Res. Q1:

What is the current situation of engineering curricula in Sudan?

Cat.	Sub-categories	Evidence
1. Curriculum	1) Outdated curriculum	a. Last revision 2012 b. On average every 10 years c. Required every 5 years
	2) Students' workload	a. The duration 10 semesters in 5 yrs. b. 171-183 credit hours/ 65 courses c. ABET Benchmark (UCB & SJSU): 120 credit hours
	3) Theoretical curriculum	a. Only two project-base courses (PBL/PjBL) b. Only three design courses c. No industrial training
	4) Irrelevant engineering materials	a. 33 out of 65 courses are not disciplined related courses
	5) Untrue claim of OBE	a. Define Desired Learning Outcomes (DLO) b. T&L activates to lead to DLOs c. Assessing student outcomes d. Reaching the final grade

Discussion:

- Students' workload
- Duration of the program
- Balance theoretical/practical components

This Category Covers Objective No. 1

Category 2: The problem of incapable engineering educators

Res. Obj2/Res. Q2:

What is the situation of engineering educators in Sudan with regards to their teaching effectiveness, qualification, and professional development?

Cat.	Sub-categories	Evidence
2. Engineering educators	6) Most of educators are not capable to graduate qualified engineers.	a. Some of them without proper PhD degrees b. Proper PhD holders, from western universities, have been trained to perform research rather than teaching. c. They miss the practical elements of the Sudanese industries. d. They stop performing research due to poor research capabilities in Sudanese universities. e. Most of them haven't worked or even seen a factory in Sudan. f. knowledge is related to the countries from where they obtained their degrees. g. No annual professional development programs and no professional development requirements. i. No KPI for educators and no accountability

Discussion:

- Pre-service qualification and in-service training
- Working conditions and hiring structure
- Accountability

This Category Covers Objective No. 2

Category 3: The problem associated with traditional T&L philosophy

Res. Obj3/Res. Q3:

What are the current teaching and learning approaches adopted by the Sudanese engineering education programs?

Cat.	Sub-categories	Evidence
3. T&L philosophy	12) Traditional T&L	a. No evidence of SCL
	14) Duration of Study	a. EC has been following the annual system b. Changed to semester system c. Only superficial change, without change in the curriculum, teaching materials, and/or traditional teaching method
	Academic Staff 15) Teaching Ranking	a. UofK- PhDs hold teaching ranking b. MSc holds TA positions. c. Other universities- MSc & PhD hold teaching ranking
	16) Poor financial compensations 17) Engaged in other academic and non-academic activities 18) No fund for research or training, 19) They are eager to help students.	a. Share of the education sector about 1.3% of GDP. b. Poor educators' working conditions. c. Lack of PD in SCL.
	20) Limited Building, Libraries, etc.	a. Observation # 6, about the limited engineering infrastructure.
	21) Laboratories	a. Good for demonstration only, not for research b. Much equipment/instruments are not functional.

This Category Covers Objective No. 3

Category 4&5: Engineering graduates and Engineering Admission

Cat.	Sub-categories	Evidence
4. Engineering graduates	22) All it takes to graduate is to memorize the materials and take the test	a. Graduates are very good in theoretical knowledge b. Graduates are very weak in practical skills
	23) The university used to link the student with the industry.	a. Before: Student are familiar with the practical element in their fields. b. Currently, training is achieved at a personal level and after graduation
	24) The training: Talent, competences, and skills.	a. Training should be impeded in the engineering curriculum; or even pre-college curriculum
5. Eng. Admission	25) Only top high school graduates	a. Admission in different engineering programs is based on high School GPA b. Changing the major is almost impossible
	26) Technology awareness is not the norm	a. Unavailability of internet connection.

Discussion:

- Low number of engineers/ with low quality
- The quality of high school graduates needs to be improved.
- a reasonable theoretical knowledge, but limited skills
- recruit foreigner engineers
- local engineering graduates are engaged in unrelated engineering professions.

This Category Related to Objective No. 1, 2, & 3

Category 6: Relationship with the industry

Cat.	Sub-categories	Evidence
6. Relationship with the industry	**Industry-** 27) Incompetent engineering graduates 28) Industry- Universities don't put the effort to collaborate with industry 29) Educators are not interested in a proper relationship between academia and the industry 30) Collaboration is done at a personal level rather than undertaking strategies **Universities-** 31) Believe that the industry is not keen on academia and/or research. 32) Industries in Sudan are not technically advanced, and they are not interested in research, but in only profitable activities.	a. Industry wants ready engineering graduates b. Prefer to recruit engineers from outside the country. c. No industrial-academic committees. d. No Programs for senior design projects that are related to real-life projects. e. Lack of industrial feedback, research and training opportunities, and learning through industry. f. Lack of internship and training programs.

Discussion:

- The Sudanese industry;
- Very weak relationship between academia & Industry.

This Category Related to Objective No. 1

Category 7 & 8: Relationship with local & international agencies

Cat.	Sub-categories	Evidence
7. Collaborations	33) Lack of collaboration with local, regional, and international institutions 34) UNESCO is the exception	a. Limited level of collaboration with: The International Network on Appropriate Technology (INAT), UNESCO and IEEE.

Category 7 Related to Objective No. 1

Cat.	Sub-categories	Evidence
8. Accreditation	35) Local accreditation by the MoHESR 36) No regional and/or international accreditation	a. MoHESR has entrusted SEC with overseeing accreditation, curriculum development process, and audit of engineering programs. b. There is no evidence of any relationship with ABET or other regional accreditation agencies.

Category 8 Related to Objective No. 1 & 2

Discussion:

- Local, regional, and international academic and professional institutions;
- Local, regional, and international accreditation bodies.

Category 9: Lack of an appropriate framework to resolve the Sudanese engineering education issues.

Res. Obj4/Res. Q4: Why there is a need for a new framework to transform the Sudanese engineering education programs?

Cat.	Sub-categories	Evidence
9. Framework	37) Need for engineering education reform.	a. All participants agreed on the need for reform.
	38) Challenges facing engineering education reform.	a. Political stability, funding, transparency, and openness to global engineering advancement.
	39) The possibility for developing transforming curriculum framework.	a. This is the main contribution of the study.

Discussion:
Resolving this issue represented one of the main contributions of this study.

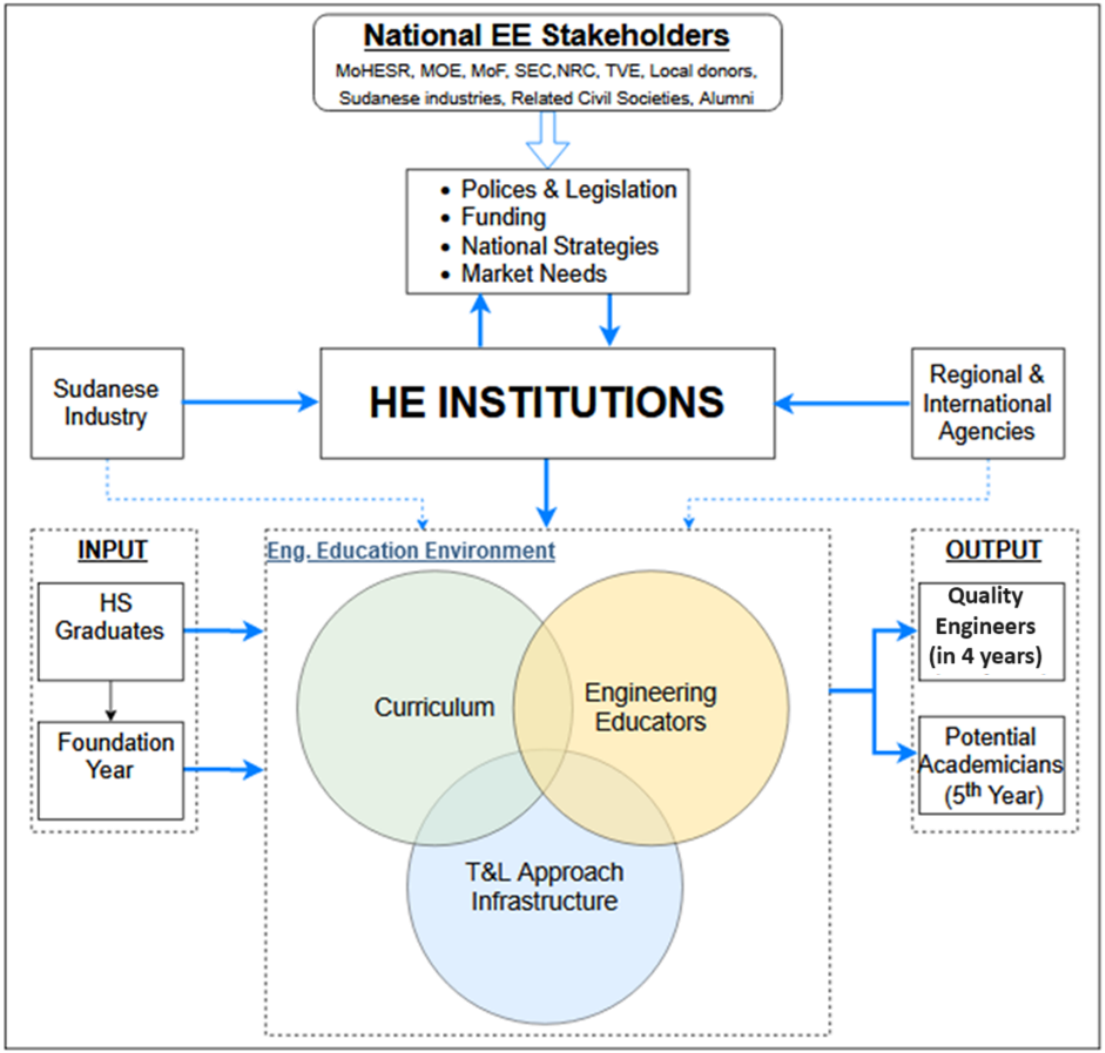
This Category Covers Objective No. 4

CHAPTER 6:

FRAMEWORK FOR TRANSFORMATION ENGINEERING EDUCATION PROGRAM IN SUDAN

Contribution to Knowledge

Framework: Transformation EE Program



Note: ABET Benchmark (UCB & SJSU), 120 credit hours, 4 years

CHAPTER 7:

7.1: CONCLUSION

7.2: RECOMMENDATIONS

Conclusion

- The study established a knowledge gap in the area of EER globally and in the context of Sudan (section 1.1.4 and 1.1.3, respectively).
- Accordingly, 4 objectives were identified, and 4 respective research questions were formulated.
- To answer them, in addition to the documentary analysis and researcher's observations, the study explored the expertise and perspectives of 7 purposeful participants on the research topic.
- The study's findings entail nine Categories: Curriculum, engineering educators, T&L methods, engineering graduates, engineering enrolment, relationship with the industry, collaborations, accreditation, and framework.
- The study determined the urgent need for a comprehensive reform of the Sudanese engineering education.
- Two main contributions:

  (1) A simple and flexible IFW for a holistic evaluation of the Sudanese engineering education system.

  (2) A framework to guide the stakeholders to formulate a process for engineering education reform in the country.

Recommendations

- Establish the purpose of the reform, along with its vision and mission.
- Develop a preliminary short- and long-term action plan, that includes specific, measurable, and attainable goals.
- Review up-to-date efforts related to the reform of engineering education in the county and identify areas of success and failure, and associated reasons.
- Set up workshops for training engineering educators and administrators.
- Organize a conference on engineering education reforms. The objectives of the conference may include:
  - Solicit participants' expertise and their feedback through formal & informal channels.
  - Finalize an action plan with a realistic timetable and associated reform budget.
  - Develop criteria and technical bodies for monitoring and evaluating the progress of the reform.

List of Publications

Publications	Journal	Status
ISSUES FACING ENGINEERING EDUCATION IN SUDAN	9TH REGIONAL CONFERENCE IN ENGINEERING EDUCATION (RCEE)	Published 2021 Non-indexed
CONCERNS FRONTING ENGINEERING EDUCATION IN SUDAN	ASEAN JOURNAL OF ENGINEERING EDUCATION, 5(2)	Published 2021 Non-indexed
FLEXIBLE CURRICULUM FOR PROMOTING SUCCESS OF CHEMICAL ENGINEERING STUDENTS AT HIGHER COLLEGES OF TECHNOLOGIES- UAE	IEE-2022 ASET CONFERENCE	Published 2022 Non-indexed
Solutions to the Engineering Education Research Activity Challenges in Sudan.	ASEAN Journal of Engineering Education, 6(2), (18-25).	Published 2022 Non-indexed
Curriculum for Promoting Success of Chemical Engineering Students at Academic Institution (X) in the Middle East (2023)	Innovative Journal of Curriculum and Educational Technology.	Submitted SANITA
Problematization of the Sudanese Engineering Education	Journal of Advanced Research in Applied Sciences & Eng. Technology	Published 2024 SCOPUS
Developing Theoretical Framework for Evaluation of Engineering Education in SSA Countries	Journal of Advanced Research in Applied Sciences & Eng. Technology	Submitted SCOPUS

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THANK YOU

Stakeholders	Rights & Privileges	Duties & Responsibilities
Stakeholders within the Discursive EE Field	Power as manifested/exercised by each stakeholder Others expected comply with	Responsibilities of each stakeholder towards other stakeholders

Stakeholders & Power (Rights/Duties) Operating within Discursive Field

Stakeholders	Rights & Privileges	Duties & Responsibilities
Governmental Agencies	Make laws, regulations, targets & standards. Demand quality & accountability.	Provide finance, policies, legislations, accreditation & recognition.
Academic Institutions	Develop strategies, policies, priorities, budget allocation	Prepare good T&L environment. Meet governmental targets & standards. Comply with laws & regulations.
Engineering Educators	Expect good T&L environment and good working conditions.	Provide quality teaching, develop adequate curricular and design appropriate assessment.
Engineering Students	Expect good T&L environment, financial aid, and employment upon graduation.	Pre-college preparedness, school fees, and good academic performance during college.
T&L Environment	Transformed curriculum, qualified educators, advanced T&L approaches, and adequate infrastructure.	
National Agencies (including industry)	Develop strategies, policies, & legislations. Identify collaboration/ Market needs	Provide funding, training, employability,
International Agencies	Develop strategies & policies. Identify collaboration/ Market needs	Accreditation, conferences, workshops, training, publications, periodicals, funding, scholarships.

Framework: Transformation EE Program

Components of the Framework	Sub-Components	Key Features	Notes
Higher Education Institutions (HEI)	All HE institutions that provide EE. The heart of the FW Independent institutions	Interaction with all other elements of the FW:	Offer bachelor/diploma The heart of the FW
National EE Stakeholders	MoHESR, MOE, MoF SEC, NRC, TVE Local donors Sudanese industries Related Civil Societies Alumni	Strategies Policies & Legislations Funding Collaboration Market needs	Dynamic features (under continuous revision) for: National strategy building; policies & legislations; necessary funding & sources; and areas & level of collaboration.
Sudanese Industry	Sudanese industry (local & foreign industries- Sudan) Global industries	Define Competencies Training Market needs Research opportunities	Industry input in: National strategies EE environment
Regional & International Agencies	Accreditation Agencies Universities Research Institutions/centers Professional Engineering Agencies Donors UN organizations Sudanese Academicians in Diaspora	Accreditation opportunities Conferences & Workshops Training (Students & Faculties) Publications & Periodicals Research Funding Scholarships	Level and areas of collaborations
Input: HS Graduates	High Schools Graduates with interest in EE	Entry point: direct admission to the engineering program or requires foundation	How to evaluate and improve the quality and quantity of engineering enrolment
Output: Enough Quality Engineering Graduates	Graduating in 4 year Potential for 5th (honor yr.)	Graduating in 4 years (Enough for a BSc. according to ABET). Additional 5th year for academic performers.	Separate workload for 4-year program, and 5-year program.
EE Environment	Curriculum, Engineering Educators, T&L Approach, infrastructure, etc.	OBE curriculum Curriculum revision every 5 years Advanced T&L methods Adequate infrastructure	Transform curriculum from content based (TCL) to OBE/CBE (SCL). Prescribed competencies. Improved infrastructures.

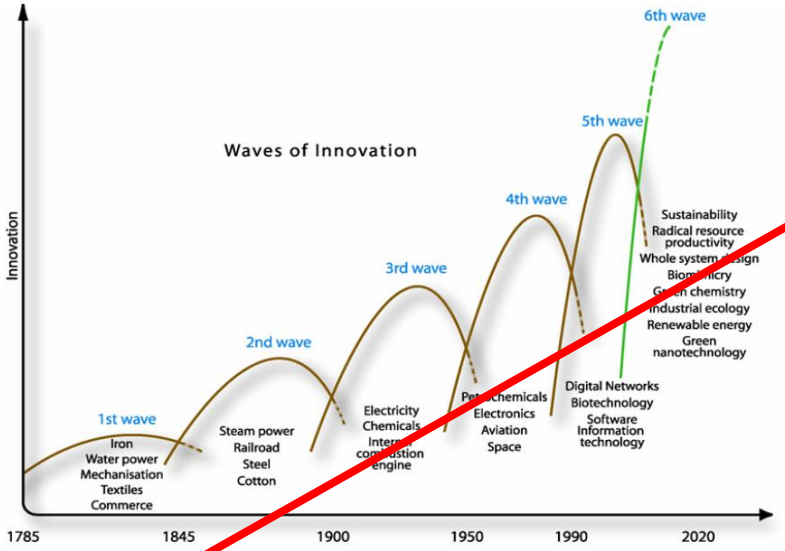
Summary of the Findings

Code	Categories	Sub-categories
Pre-defined coding	1. Curriculum Res. Obj 1, Res. Q1	1) Outdated curriculum, 2) Students' workload, 3) Theoretical curriculum 4) Irrelevant engineering materials, 5) Untrue claim of OBE
	2. Engineering educators Res. Obj 2, Res. Q2	6) Most of educators are not capable to graduate qualified engineers, 7) No annual professional development programs, 8) No professional development requirements, 9) No KPI for educators, 10) No accountability, 11) UofK affiliation is a prestige rather than for the financial compensation
	3. Teaching & learning (T&L) Res. Obj 3, Res. Q3	T&L Philosophy: 12) Traditional T&L is the norm, 13) No evidence of SCL, 14) Duration of Study Academic Staff: 15) Teaching Ranking, 16) Poor financial compensations 17) Engaged in other academic and non-academic activities, 18) No fund for research or training, 19) They are keen to help students. Infrastructure: 20) Limited Building, Libraries, etc., 21) Laboratories
	9. Framework Res. Obj 4, Res. Q4	37) Need for engineering education reform, 38) Challenges facing engineering education reform, 39) The possibility for developing transforming framework
Data-driven coding	4. Engineering graduates Res. Obj 1, 2, & 3	22) All it takes to graduate is to memorize the materials and take the test. 23) The university used to link the student with the industry. 24) The training: Talent, competences, and skills.
	5. Admission of engineering students Res. Obj 1, 2, & 3	25) Only top high school graduates, 26) Technology awareness is not the norm
	6. Relationship with the industry Res. Obj 1	**Industry-** 27) Incompetent engineering graduates, 28) Universities don't put the effort to collaborate with industry, 29) Educators are not interested in a proper relationship between academia and the industry, 30) Collaboration is done at a personal level rather than undertaking strategies. **Universities-** 31) Believe that the industry is not keen on academia and/or research, 32) Industries in Sudan are not technically advanced, and they are not interested in research, but in only profitable activities.
	7. Collaborations Res. Obj 1	33) Lack of collaboration with local, regional, and international institutions. 34) UNESCO is the exception.
	8. Accreditation Res. Obj 1, 2	35) Local accreditation by the MoHESR 36) No regional and/or international accreditation

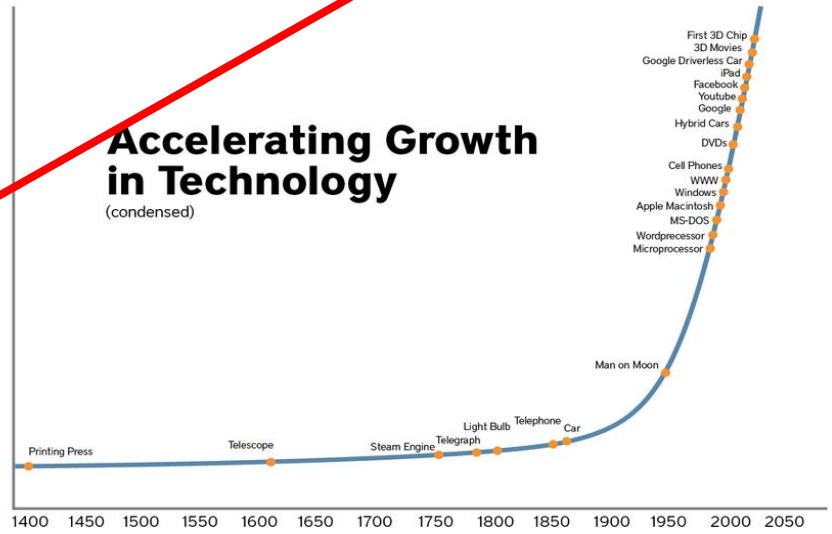
Research Background

21ST Century Engineering Profession

Waves of Innovation (Hargroves, 2005)



Accelerating Growth in Technology- https://images.app.goo.gl/gjr9cjeuJxhjZkWXA



❖**Three Components of EE:** *knowledge, skills, and attitudes*

'Knowledge is the data base of a professional engineer; skills are the tools used to manipulate the knowledge in order to meet a goal dictated or strongly influenced by the attitudes.' (Rugarcia et al., 2000)

FRAMEWORK FOR TRANSFORMATION DEVELOPMENT OF SUDAN UNDERGRADUATE ENGINEERING EDUCATION PROGRAM

A TRANSFORMATIONAL FRAMEWORK FOR THE DEVELOPMENT OF UNDERGRADUATE ENGINEERING EDUCATION PROGRAMS IN SUDAN