CONCEPTUALIZATION OF THE DEVELOPMENT STS MATERIALS

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©Ontario International Development Agency ISSN: 1923-6654 (print)
ISSN 1923-6662 (online). Available at http://www.ssrn.com/link/OIDA-Intl-Journal-Sustainable-Dev.html

Abstract: This study presented the conceptualization of Development Materials (STS module), which was part of a bigger study to establish a science, technology and society (STS) foundation in the Ninth Grade Science curriculum in Palestine. It was discussed the STS approach and constructivism, followed by a discussion of constructivism and instructional design. It was then described the instructional design models used as a guide in developing the STS teaching and learning materials (modules) in this study. Furthermore, this study discussed the formative and summative evaluation carried out in this developmental research and the appropriate methods employed for the formative and summative evaluation. Some essential features and criteria of high-quality teaching and learning materials and the process of material development were also discussed. Finally, this study discussed the conceptual framework of the Development Materials (STS module).

Keywords*:* Science, technology, and Society (STS), Constructivism, Instructional Design; STS Materials

INTRODUCTION

The rapid explosion of knowledge in all the different branches of science has led to change in the goals of science. The change is from focusing on knowledge to the application of this knowledge in the various affairs of life. Responsiveness to individual needs is not the only application of science (technology); it must also enhance the development and welfare of citizens (the community). Therefore, daily life is much influenced by the scientific and technological applications. Consequently, it is important to begin from daily life experience in the teaching and learning of science. The teaching and learning of science within the context of human experience (daily life context) is STS as defined by the NSTA (2006). It has been found that students will be interested in learning science in a context they recognize [1].

Around the world the term STS has its own definition and use according to the time and place of usage. Some examples of these different definitions of STS in science-related curricula which are known globally as stated by Aikenhead [2] are: "science-technology-citizenship; nature-technology-society; science for public understanding; citizen science; functional scientific literacy; public awareness of science; variations on science-technology-society-environment; and cross-cultural school science". These examples of STS categories in science are generally considered as tools for assisting people to achieve the goals of "science for all" and "scientific literacy" besides increasing the level of interest among disinterested students to take part in school science.

STS and Constructivism

More than just a theory of learning, constructivism has been considered as the dominant paradigm in science education since over three decades ago [3].

Even in the early years of the first decade of the new millennium, the wide range of constructivist concerns can be seen in the subheadings of science education articles such as “A constructivist view of learning,” “A view of science,” “A constructivist view of teaching,” “Aims of science education,” “A constructivist view of curriculum,” and “A constructivist view of curriculum development” [4]. To Fleury [5] constructivism has the potential to transform educational theory (p. 156). According to Matthews [4], although constructivism began as a theory of learning, it has expanded its domination; it is now a theory of teaching, a theory of the origin of ideas, a theory of education, and a theory of both personal and scientific knowledge. Constructivism presents itself not only as an ethical and political theory; it is also a learning, a teaching, and an epistemological theory. Beyond doubt, it is a major theoretical influence in contemporary mathematics and science education.

Literature review shows that constructivism is often associated with the variety of educational and pedagogical approaches in the literature of STS education [6] as noted earlier. Yager [7] for example, has placed STS as a paradigm shift within the broader learning theory of constructivism. He wrote that teaching techniques that aid students in formulating meaning for themselves have been suggested and evaluated, particularly by educators in STS and that “such teaching strategies are now called constructivist teaching, even though that term is usually reserved for a way of describing human learning. STS by definition requires such teaching” (p. 225).

Aikenhead defined constructivism as a characteristic for developing STS textbook materials [8]. He stated that STS science transfers the focus from an academic scientist’s knowledge transmission to the student’s knowledge construction. This student-oriented perspective emphasizes “the basic facts, skills, and concepts of traditional science, but does so by embedding that science content in social-technological contexts meaningful to students” (p. 34). Hence, it deals with practical issues in the relationship between constructivism and STS analysis and its impact on student-centeredness and higher order thinking. It is clear from Yager’s discourse that his linking of STS to constructivism is largely related to students being practically involved in the process, and not necessarily because STS is not difficult for students to integrate into their conceptual structures. Yager did not specifically attempt to explain students’ experiences with STS as a way to make conceptual representations of the world and in fact took a pedagogical constructivism stance [9].

Moreover, Lutz [10] stated that STS can be seen as a type of conceptual change and explained that conceptual change is most likely to occur “when current issues are under investigation, and result in a perceived need for a more adequate explanation or viewpoint than that which the observer currently holds” (p. 43).

Cheek [11] further developed and sought to organize constructivism as a theoretical framework for STS. Cheek focused on constructivism as students learn the content of science, to the area of students’ conceptions about science, technology, and society. STS education is thought to help students in changing their naïve conceptual understanding of socio-scientific issues. Moreover, in revealing students’ ideas on science, researchers need to unearth students’ conceptions of politics, economics, and social functions in order to develop STS [11]. In the same process, Aikenhead and Ryan [12] developed a questionnaire that elicits students’ conceptions of the nature of science, technology and society interactions (VOSTS). Many researchers have used the same instrument or an adapted version to test students’ or teachers’ conceptions of STS.

Constructivism has two basic assumptions; first, learners have a good chance to learn when faced with real issues and problems; second, effective learning requires meaningful, open- ended, and challenging problems for learners to resolve [13]. Hence, the assumptions of constructivism are suitable for the goal of the present study. This is because the research questions of this study are related to the effects of real-life issues and problems of STS among the students.

The mechanism of constructivism for STS is easier for students to integrate into their conceptual structures [14] since STS involves learning of science concepts in the context of real life experience and as applied to real life problems and issues [10]. In addition, as a problem-based learning STS is open to constructivism because students are actively involved in finding solutions to problems and not only being lectured about content. Students also develop a better conception of science since they are dealing with real world, interesting and meaningful problems. STS utilizes the constructivist approach for learning; it focuses on current issues, local contexts as well as personal relevance ([15], p. 2).

Constructivism and Instructional Design

Instructional design is the systematic process of translating principles of learning and instruction into plans for instructional materials and activities. It prescribes a process of analysis and identification of learning needs and learning goals in order to develop instructional materials, learner activities, and evaluate learning methods [16]. Instructional design allows educators to identify the performance problems, determine the goals and objectives, define the learners and their needs, formulate strategies to meet needs and goals, evaluate learning outcomes, and assess whether goals, needs and objectives are met [17].

Differences exist between the constructivist view and the objectivist approach to instructional design. Reigeluth [18] argues for a 'new mindset' to combine constructivist elements in the instructional design models. Many educators indicate that constructivist values influence instructional design [19], [20], [21]. Lebow [19] proposes a number of principles as constructive values, which identically reflect the objectives of the current research.

"Five Principles towards a New Mindset" was introduced by Shariffuddin [17] as constructivist values that might impact instructional patterns.

Principle 1 provides a protective shield for the learner in front of the probable destructive effects of instructional exercises by: (a) Putting more emphasis on the emotional area of learning (b) Providing individual instructions relevant to learners (c) Supporting learners in developing their capabilities, perceptions, and ideas that lead to learning process self-regulation (d) Balancing tendencies to control the learning situation with willing to improve individual independence.

Principle 2 provides a context for a type of learning which encourage self-dependence and relevancy.

Principle 3 includes the reasons of learning within learning activities.

Principle 4 encourages self-organized learning by improving capabilities and perceptions that make learners expect growing responsibility for the promotional reorganization period.

Principle 5 strengthens the learners' willingness to take part in deliberate learning processes, specifically by supporting the "strategic exploration of errors" [19].

The principle behind constructivism for pedagogical designers is that, if each person admits his responsibility for conducting knowledge, then designers can set and guarantee a standard series of issues for learning, "as we have been taught to do" [22]. In the same paper, Jonassen presents the following connotations of constructivism for instructional patterns; to him intentional knowledge building will be facilitated by the assistance of learning situations that: (a) Provide several aspects of reality- do not oversimplify instruction by giving the natural complication of the universe. (b) Provides real exercises - considering all aspects of its situation (c) Presents actual-world, case-oriented learning situation, not prepared pedagogical procedures (d) Increase conscious practice (e) Activate content-based and context-based knowledge formation

Jonassen [22] noted that constructivism promotes the creation of relevant learning environments that facilitate learners' knowledge construction. This is because, unlike traditional systems approaches, constructivism has a different base of assumptions about learning and puts forward new instructional principles. Applying constructivism to instructional design offers specific advantages, for instance, more independent problem-solving, more meaningful learning outcomes and greater flexibility in design as well as instruction activities [23]. Relying on first principles, the instructional design recommendations are as follows: Learning is facilitated when learners are engaged in solving real-world problems; when existing knowledge is activated as a foundation for new knowledge; when new knowledge is demonstrated to the learner; when the learner applies new knowledge; and lastly, when new knowledge is integrated into the learner's world [24].

The application of constructivism to instructional design has certain advantages such as more meaningful learning outcomes, more independent problem-solving capability and more flexibility in both design and instruction activities.

Thompson [25] believes that instructional hypotheses and patterns as discussed related to the models above help teachers and instructors by: (a) Speeding up the process by helping teachers to focus and assist as bases of procedural progress (b) Assuring that all parts of the instruction are considered, interrelated and supportive towards each other.

Figure 1 represents how constructivism in instructional design helps in changing students' concepts and reshaping their mind-set. This can be achieved by developing STS materials that infuse the STS elements within the science teaching materials. Developing STS materials enhances student learning in three ways: (a) it provides a meaningful context of their learning by linking it to their daily life routines; (b) it strengthens the relationships between science, technology and society; and (c) it also links values with STS and considers values as the most important aspect of STS. In the next section, instructional design will be discussed further.

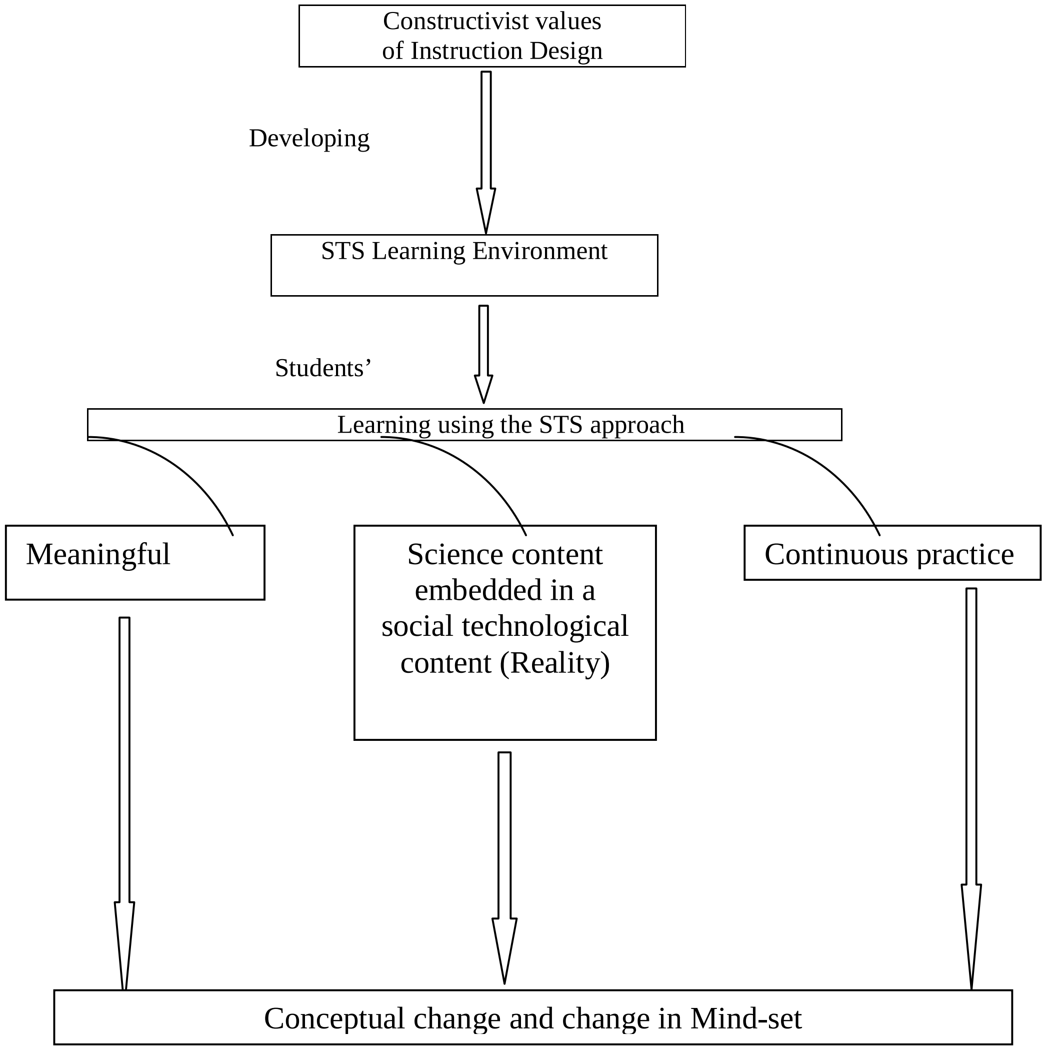

Figure 1: Constructivism, instructional design and STS.

Instructional Design Models

Instructional design models focus on the best methods for delivering comprehensive instruction based on theories of learning. Instructional design provides the methodologies for implementing instructional theories. Dorin, Demmin, and Gabel [26] suggested that instructional design models look at a model as a mental picture that helps designers to understand things they cannot observe or experience directly. Furthermore, models are successful aids used to help designers describe and understand the systematic process of using instructional design and learning theories in designing instructional materials, information resources, activities, and evaluation methods [27], [28]. Many instructional design models exist but at the macro-level, all have three items in common: (a) identifying the outcomes of the instruction, (b) developing the instruction, and (c) evaluating the effectiveness of instruction [29]. Some instructional design models are best fitted for multiple courses, single class, rapid prototyping and/or lesson level development [29].

This study will review six instructional design models. After the review, based on the instructional design models it presents the core elements as systemic approaches to be used in this present research.

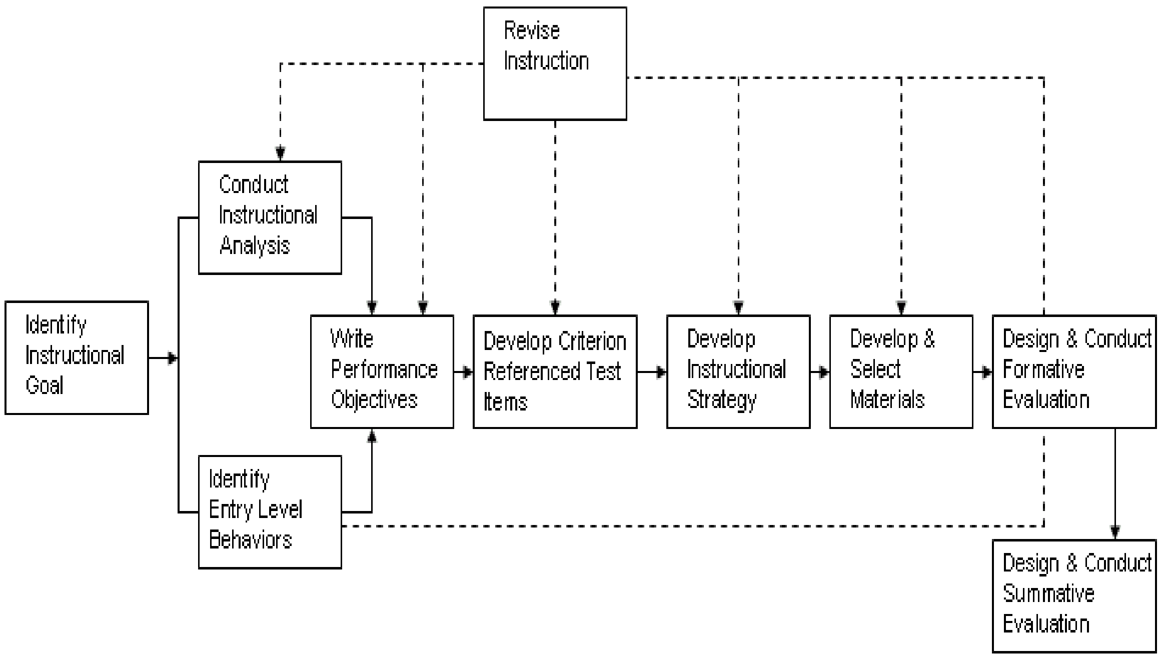

Figure 2: Dick and Carey model of instructional design [33].

Reflective, Recursive Design and Development Model

The Reflective, Recursive Design and Development (R2D2) model is deeply rooted in constructivist learning principles. Developed by Willis [21], the R2D2 model is a team-based instructional design model and is mainly targeted at software development; the R2D2 model appears most appropriate for developing electronic instruction.

Recursion, the first concept, allows the designer to make revisions at any time during the instructional design process on any aspect of the design.

Reflection means instructional designers gain input from many stakeholders during the design process. Two other principles underscoring the R2D2 model are not identified in the name; they are non-linearity and participatory design.

According to this model, the instructional design process can start at any point (Non-linearity). The team need not start with detailed objectives; these will emerge at an appropriate time as the work progresses. Participatory design means that people who use the instruction most frequently should be involved in the design in all stages. The design team should be cross-functional, and made up of instructional designers, subject matter experts, and end-users [21].

The R2D2 model process allows inclusion of traditional instructional design elements for instance instructional objectives, learner analysis, and task and content analysis. This model involves a four-stage process for design and development: Component Design, Single Path Prototype, Alpha Version, and Beta Version. In essence, the R2D2 model is a user-based, iterative instructional design model [21].

ADDIE Model

Instructional design is the planned approach to the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) of learning materials and activities. The ADDIE model is aimed at a learner-centered rather than the traditional teacher-centered approach to instruction, to allow for effective learning. Hence, each component of the instruction is geared towards the learning outcomes, which have been adopted following a comprehensive analysis of learners' needs. Sometimes these phases overlap and can be interconnected; however, they offer a dynamic, adaptable guideline for devising effective and efficient instruction.

The ADDIE Model is an iterative instructional design process; formative evaluation of each phase yields results which may make the instructional designer re-visit a previous phase. In short, the end product of one phase becomes the starting point of the next phase [30].

Kemp Instructional Design Process

The Kemp model of instructional design is based on ten elements/activities: 1) Learning needs, Goals, Priorities/Constraints, 2) Topics- Job Tasks Purpose,

3) Learner Characteristics, 4) Subject Content Task Analysis, Learning Objectives, 6) Teaching/Learning Activities, 7) Instructional Resources, 8) Support Services, 9) Learning Evaluation, and 10) Pre-testing ([31], p. 11). According to Kemp, even though the ten steps have a logical order, it is not absolutely necessary to start at step one and finish at step ten; each design application will be unique and may require designers to begin at different points. Kemp has developed a model of these steps, illustrated by an oval without a starting point and without an end.

Dick and Carey Systematic Design of Instruction

The Dick and Carey Systematic Design of Instruction (Systematic Design) is an instructional design system which pays attention to the skills and knowledge to be taught [32]. The model has ten steps, namely: identify instructional goal(s), carry out instructional analysis, identify entry level, define performance objectives, develop criteria and test items, devise instructional strategy, develop and choose instructional materials, design and do formative evaluation, design and carry out summative evaluation, and, at any point, review the instruction. This model provides a clear structure and a systematic approach towards course instruction, but is lacking in flexibility. While the Dick and Carey model has many of the same features as the Kemp model, the Kemp model seems to be more suited for course level or curriculum level design because of its flexibility.

Dick, Carey, and Carey [33] revised a famous model that involved sharing common attributes in addition to recent educational trends including constructivism [28], [29]. In their instructional design model Smith and Ragan [28] proposed three main stages: analysis, development and evaluation. This model was developed based on the common model created by the Dick and Carey [34] systematic approach for designing instruction.

Model of Instructional Design Based on Constructivist Theory “New Model”

The new instructional design model called new model combines the system approach, Dick and Carey’s Model, Gerlach and Ely’s Design Model, Işman’s Model, and the constructivist theory approach. The constructivist theory which affects the basic foundations of the “New model” stages emphasizes how people learn and the nature of knowledge. Learners construct their own understanding based on their unique experiences in accordance with the beliefs of constructivism theory. The learners construct their own meaning from learning experiences according to constructivism. In addition, learners apply their knowledge personally in a meaningful context. The activities are based on discussion and collaboration among students. Assignments that reflect real life conditions play an important role. Interaction and reflection are important. Throughout the process assessment is integrated rather than in the final products [35].

The learners are the center of the equation in the constructivist approach; the learner constructs rather than passively absorbs knowledge. It is based according to how the learners’ understanding is currently organized. Constructivism is based on the following basic premises: knowledge is constructed from experience; learning is a personal interpretation of the world; learning is an active process in which students attain meaning based on experience; conceptual growth comes from the negotiation of meaning, sharing multiple perspectives and changing our internal representations following collaborative learning; learning must occur in a realistic context; tasks should be integrated with testing and testing should not be an isolated activity [36].

Stage of “New Model” Instructional Design

The basic stages of this model are input, process, output, and feedback. Input stage consists of five different steps that create the main stage: Needs assessment step, writing instructional goals, instructional analysis, writing instructional objectives and selecting instructional materials. Through the needs assessment step the instructor can determine performance gaps or identify the discrepancies between current outcomes and desired outcomes for an organization. When the performance gaps have been identified, the designers will determine what they want the students to be able to do after they have completed the instruction. To determine what the students are required to learn in order to meet the instructional goals the instructional analysis is done. Generally this analysis engages the skills and procedural knowledge that the students have. In order to identify the relevant skills and information required for students to achieve the goal it is a kind of procedure applied to an instructional goal. The next step is to determine the learning objectives or what students will be able to do when they complete the instruction. The vital step is to choose the most appropriate materials for the instruction [35].

The second stage is called process; this stage consists of three main steps. During the process the implementation part begins. Teaching and the organization of time and milieu are the main part of implementation. The strategy of teaching is a general plan of activities to reach an instructional goal; it consists of the sequence of intermediate objectives and the learning activities leading to the instructional goal.

Lastly is the stage involving evaluation of student performance. In this stage it is very important to develop evaluation instruments to assess the objectives. Once more this stage consists of formative evaluation, revision, and summative evaluation. In order to know whether the learners achieved their goals or not after each specific subject teaching, formative evaluation is used. If they did not achieve the goals, the teacher goes back to the first stage which is the input and revises the design model. On the other hand, if the students achieved their goals and teacher expectations are met with the results and goals, then the teacher gives the summative evaluation and assesses the students' performances. Formative evaluation is the evaluation designed to collect data and information used to improve a program or product; it is conducted while the program is still being developed. Evaluation designed and used after implementing an instructional program and completing formative evaluation is called summative evaluation. Summative evaluation is aimed at presenting conclusions about the worth of the program and making recommendations about its adoption or retention. During the last stage, which is the feedback stage, the teacher gives feedback to the students [35].

Seels and Glasgow Model (Product-oriented)

The Seels and Glasgow model has three phases which are presented in Figure 3: needs analysis, pedagogical or instructional design, followed by implementation and evaluation.

Needs Analysis, the first phase and involves defining of instructional goals, requirements, and context. Instructional design, or the second phase, begins after phase one is finished and involves six steps: task analysis; instructional analysis; objectives and tests; formative evaluation, materials development, instructional strategy and delivery systems. All these are connected by feedback and interaction. The third or implementation/ application and evaluation/appraisement phase entails the materials development and production, training delivery, and summative evaluation. The steps and phases in this model, although often applied iteratively, can be applied in a linear way. The steps of the instructional design phase are interdependent and concurrent and may involve iterative cycling ([37], p. 43). Product-oriented models are normally used in producing an instructional package.

Producing a product requires a team and a significant resource commitment to stay within time and budget, and hence requires strong project management. The team must have an experienced instructional designer to do some front-end analysis, develop the materials and perform a lot of formative evaluation. Products are likely to be widely distributed using a moderate to high technical delivery media [37].

Instructional Design for the Present Study

Each instructional design model emphasizes the importance of needs analysis, goal specification and design of learning objectives, materials design based on needs analysis and aims, development of appropriate instructional strategies, formative and summative evaluation, and improvement of materials based on results of evaluation. In other words, the abovementioned instructional design models emphasize the core elements of analysis, design, development and evaluation. For a systemic approach, the researcher of the present study followed four main steps of instructional design in this research. Moore, Bates, and Grundling [38] defined these steps (Figure 4).

Analysis: this phase is the basis for all other instructional design phases. Most of instructional design models start at this phase. The designers need to collect all related information to resolve a wide range of challenges, contradictions and ambiguities. It is important to gather and analyze all relevant information; thus the designer needs to consult and interview the experts [38].

Design: in this phase designers start to plan a strategy for developing the instruction based on the outputs of analysis. Translating the results from the analysis phase into design specifications means that the designers require a strong background in learning and instructional theory. The main aim of the design phase is to determine the purpose of the instructional materials, the learning outcomes and objectives, teaching and learning strategies and the implementation strategy for evaluating instructional material effect and effectiveness. The aim of designing instructional materials is to enhance capabilities and achievement in real-life settings [38].

Development: this phase is aimed at producing the lesson plans and lesson materials. The appropriate link here is to link instructional design procedures with plan management principles. This phase encompasses material validation. The validation process includes formative evaluation involving collecting and interpreting individuals' opinions on the learning and instructional materials. Designers in this phase would probably deal with questions such as: How do learners react to the learning experience? How effectively do the materials teach? What are the outcomes of the learning? What unanticipated problems arose? What must be adapted? [38]. This phase also involves the implementation stages. In this stage, the designer determined the problems that arise when the instructional material is implemented by the users.

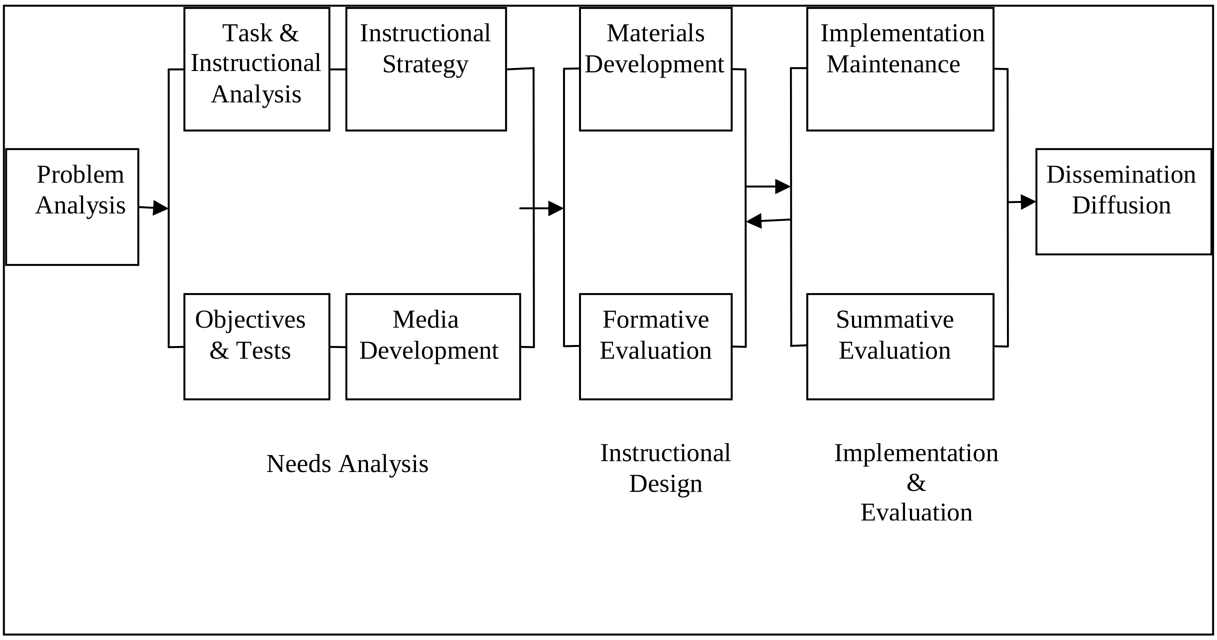

Figure 3: The Seels and Glasgow model [37].

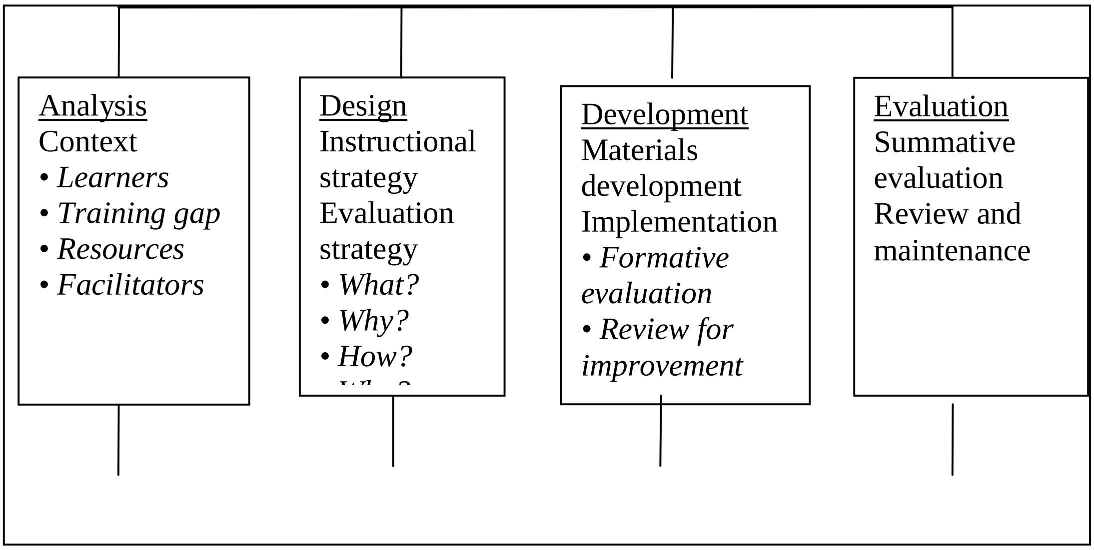

Figure 4: Core elements of instructional design models. Source: [38].

Evaluation: This phase deals with instructional effectiveness and efficiency. The evaluation should be within the completed instructional design process, within phases, between phases, and after implementation. Evaluation may be formative or summative [30]. According to Moore et al. [38] evaluators examine issues such as: What is the impact of the new learning materials on the institution? How are grades and graduation rates or job performances affected? Are the learning objectives relevant? Are the materials being used correctly? Is the course content relevant? What aspects need to be adapted or updated?

Formative Evaluation in Development Research

Nieveen [39] proposed four generic criteria for high quality interventions, namely: the intervention components must rely on state-of-the-art knowledge (content validity) and all components should be consistently interrelated with each other (construct validity). Intervention meeting these criteria is regarded as valid. High-quality intervention is also evident when end-users (for instance teachers and students) consider the intervention to be usable and that it is easy for them to use the materials in congruence with the developers' intentions. When such conditions are met, these interventions are termed practical. A third principle of high quality interventions is that they lead to the desired outcomes, namely effective interventions [39]. The criterion of practicality in the prototyping stage has received much attention in formative evaluation. Furthermore, effectiveness becomes even more important in later iterations. At the end, in the assessment stage of summative evaluation, practicality and effectiveness will be emphasized [40].

Formative evaluation is a necessary assessment in present developmental research. The Joint Committee on Standards for Educational Evaluation (1994) has defined evaluation as "the systematic assessment of the worth or merit of some object." Lincoln and Guba [41] stated that merit refers to the object's inherent, intrinsic value, and worth of the object is defined as its contextually determined, place-bound value.

Scriven [42] distinguished between formative and summative evaluation. Formative and summative evaluations serve different functions. The function of formative evaluation is "to improve", such as generating suggestions for improving an object. Thus, formative evaluation focuses on uncovering shortcomings during its development process.

On the other hand, the function of summative evaluation is "to proof" where evidence is gathered to prove the effectiveness of the intervention and find arguments that support the decision to continue or terminate the project. It is also noted that there is no clear distinction between formative and summative evaluations. Relevant points of improvement revealed by formative evaluation in turn may be used by summative evaluation for continuation of a product. For example, an improved version of an intervention may be the intention of a formative evaluation but the results of such evaluation are taken into account while developing a second release of the product [40].

Appropriate Methods for Formative and Summative Evaluation

Plomp et al. [40] has identified a five-stage combination for formative and summative evaluation: testing; expert appraisal; walkthrough; micro-evaluation; and try-out. Firstly, testing is where the design research team tests the design with a checklist of important features of the various components inherent in the prototype.

Secondly, expert appraisal is where a group of experts give opinion on a prototype of the design. A guideline with central questions of the design research team is used in the interview session with the experts.

Thirdly, walkthrough is conducted with the design research team and one or a few representatives of the target group to go through the various parts of the intervention. Fourthly, micro-evaluation is conducted with a small group of target users, comprising learners or teachers. This stage involves evaluating parts of the intervention being used apart from its normal user setting. Here, the respondents are being observed and interviewed by the evaluator.

Finally, try-out is a stage where a user group comprising teachers and learners try using the materials under normal circumstances.

If the evaluation focuses on practicality of the intervention, the following evaluation activities are common: observation, interviewing, requesting logbooks, administering questionnaires. If the evaluation focal point is the effectiveness of the intervention, evaluators may decide to request learning reports and/or give a test. Summative evaluation methods, such as quasi experiments, surveys and accompanying case-studies, follow these formative evaluation activities as soon as the intervention has become fully grown and has been implemented in educational practice ([40], p. 95).

Materials Development

Developing materials is an integral part of curriculum development and educational change processes. Such materials may include syllabi, curriculum guides, courses, resource units, lists of goals and objectives, texts, and other documents that deal with the content of the education. Materials play a fundamental role in classroom instruction. As such, curriculum processes are those procedures involved in creating, using, and evaluating the curriculum that is represented in various products or materials. These materials contain content and skills for students. Among those skills are for students to learn, detail connections among ideas, and provide contexts for teaching these ideas. In addition, these materials suggest sequences for activities [43].

According to Rogers [44], high-quality materials should include the following features: (a) Reflect the results of a proper needs analysis (b) Be industry verified (c) Reflect learning goals and objectives (d) Be developed/adapted as a part of a systematic curriculum development process (e) Support and identify instructional strategies including pedagogy and assessment (f) Undergo pilot and field-testing (g) Be continuously evaluated (h) Be revised based on evaluation evidence

The process of material development can be summarized into eight steps [45]. The first step is needs assessment which is the starting point for developing learning materials. The learners prefer to learn something directly beneficial to them. At the same time, learners learn things that are relevant to their needs. This can be done by collecting data about the living environment, and problems and needs of the people. Various approaches are used for data collection, such as asking learners questions. Additionally, the approach may include visiting learners' houses. Another approach would be a discussion with people individually or in groups while joining their activities and observing their daily routine.

The second step is the preparation of a curricular unit. The researcher has to prepare an outline of the learning materials which is known as the curricular unit. This curricular unit helps material developers select, adapt, and develop learning materials as planned. A checklist is used for the curricular unit which has the following components: (a) a theme to describe the learning material; (b) the target learners of the learning material; (c) objectives of the learning material; the objectives have to be specific, measurable, achievable/attainable, result-oriented, and time-bound; (d) content to be included in the material; (e) format to be used to convey the content of the learning material; (f) information on how the material is going to be used in the teaching-learning process; and (g) the time required to use the material while in the learning process.

The third step involves material preparation. This can be done through any of these methods: preparation of learning materials, selection of learning materials which are readily available, adaptation of learning materials, and development of new learning materials.

The fourth step is pre-test. Pre-test is conducted on the learning materials produced to assess its quality. This enables the learning material to be further improved before finalization.

The fifth step is revision and finalization. Here the information from the testing will provide the material developers with a clearer idea whether the learning material produced is suitable for use or not, after the pre-test. Improvements are made to the learning material based on the tested data. Here, the material developers can either make changes or corrections to the learning material. When the material is through with improvement it is ready for the next step.

The sixth step involves duplication where the corrected version can be used for mass production. The seventh step is application of the learning material in the learning and teaching environment. In the learning process, the characteristics of the learning materials and the objectives help determine their uses. For example, the learning materials may be used for songs, posters, drama, or video. This helps to motivate the learners. To ensure learner participation, the learning materials may be used as a game, dialogue, role play, or even drama. Moreover, the learning materials may also be used in the form of leaflet, chart, or video for transmission of instruction and knowledge.

The final step is evaluation which is to measure whether the learning material produced meets the objectives as defined earlier. Evaluation methods comprise post-testing, as well as getting feedback from users, facilitators, and learners.

The whole framework goes into three phases, namely, needs analysis phase, versioning phase and assessment phase. These three phases if adopted correctly would result in developing STS teaching and learning materials that have nine characteristics as indicated in the shaded boxes in Figure 5.

The following are the details of the conceptual framework of the study.
Review of Palestinian literature, content analysis of the ninth grade science textbooks and curriculum framework analysis have revealed the problems (Gap) in Palestine education and have exposed the needs of the Palestinian science students. Based on the gap, the learning objectives and learning outcomes for STS integration were determined by the researcher. The learning objectives and learning outcomes were refined by using Delphi technique.

The first draft of the STS teaching and learning materials were developed based on learning objectives and learning outcomes, principles and STS teaching model and Constructivism theory. The experts and teachers' appraisal were helpful in improving the materials as valuable suggestions were generated. In addition, interviews and discussions were carried out with the teachers and students to evaluate the practicality of the STS teaching and learning materials (try out - formative evaluation). The perceptions of teachers about the final developed STS modules and students learning outcomes (field test - semi-summative evaluation) were also carried out to determine the effectiveness of the STS teaching and learning materials (modules) based on the variables of gender and location.

The Summary of the Study

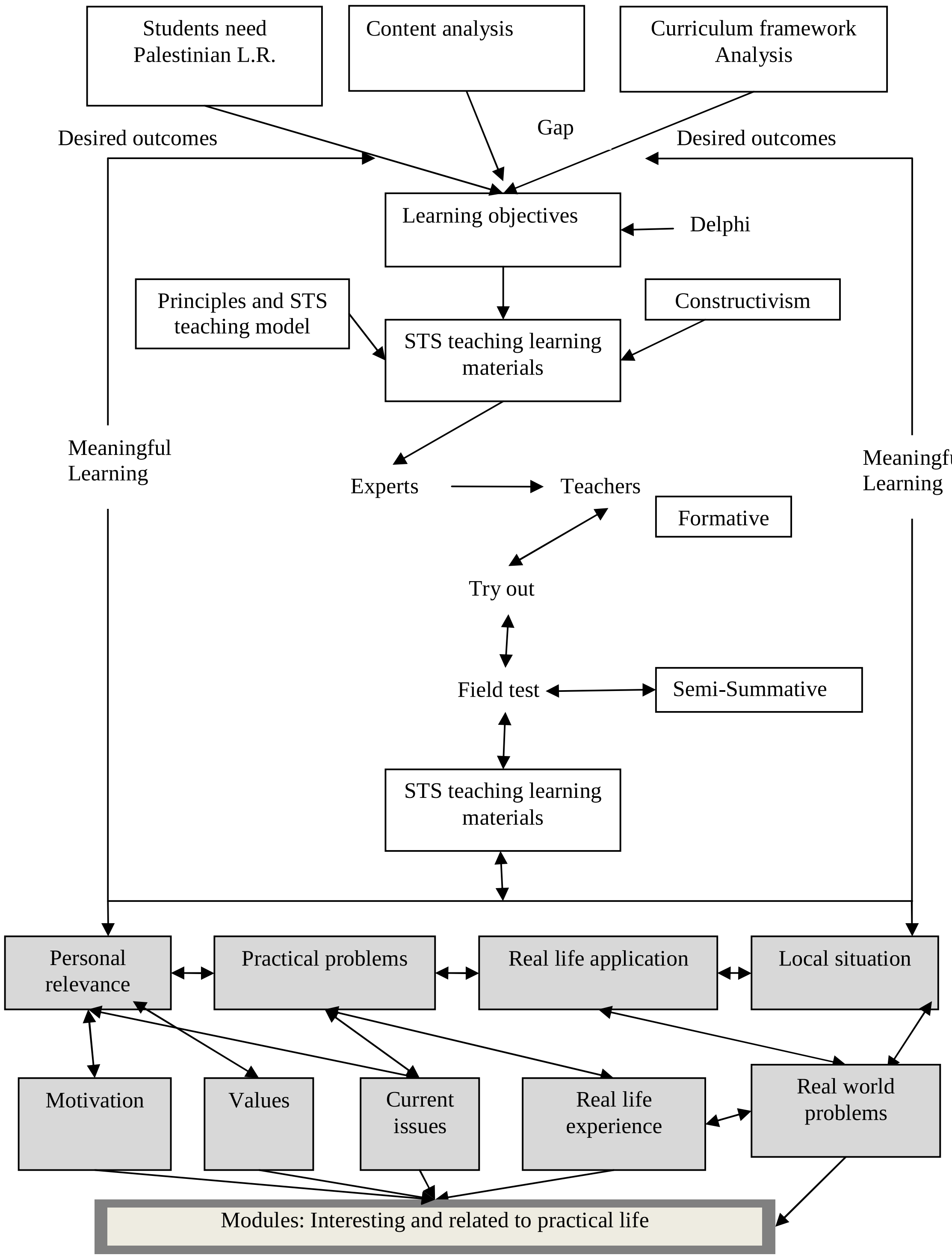

Figure 5: The conceptual framework for the study

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