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Reengineering agricultural technology education based on constructivism, engineering design and systems thinking in farming systems of Khuzestan province, Iran

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The main objective of research was reengineering agricultural technology education based on constructivism, engineering design and systems thinking in farming systems of Khouzestan province, Iran. The method of research was correlative descriptive and causal relation. A random sample of agricultural extension educators of Khouzestan province, Iran (n=105) were selected for participation in the study. Based on the constructivism the top six ranked items in favorable conditions were: (1) Emphasizing discourse and collaboration; (2) Ability to communicate ideas; (3) Developing self thought and reliance; (4) Discovering knowledge through group work; (5) Programs place a high value on field work, and (6) Using problem solving methods. Based on engineering design the top six ranked items in favorable conditions were: (1) Communication and analytical skills; (2) Interpersonal skills: teamwork, group skills, attitude, and work ethic; (3) Problem-solving and creative thinking; (4) Formative evaluation; (5) Contributions from both social and natural science in the educational process, and (6) The ability to negotiate and influence, and self-management. Also based on systems thinking, the top six ranked items in favorable conditions were: (1) Focus on the needs of farmers; (2) Negotiating assessment processes; (3) Considering farm as system; (4) Need for a more holistic understanding; (5) Helping learners confront personal beliefs and create their own theories of learning, and (6) Providing learners with opportunities to examine, analyze, and reflect on their own thinking.

Key words: Agricultural technology education, constructivism, engineering design, systems thinking.

INTRODUCTION

A national employer survey identified desired job skills needed in today's workforce. Today's jobs require a portfolio of skills in addition to academic and technical skills. These include communication skills, analytical skills, problem-solving and creative thinking, inter-personal skills, the ability to negotiate and influence, and self-management (Kelley and Kellam, 2009). Dearing and Daugherty (2004) conducted a study to identify the core engineering-related concepts by surveying 123 professionals in technology education, and engineering education. The top five ranked concepts were:

1. Interpersonal skills: teamwork, group skills, attitude, and work ethic,
2. Ability to communicate ideas: verbally, physically, and visually,
3. Ability to work within constraints/ parameters,
4. Experience in brainstorming and generating ideas,

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5. Product design assessment: Does a design perform its intended function?

Groves (2008) pointed out, using a constructivist approach in the education where the educator encourages learner to discover knowledge through group work, inquiry, and experimentation. Educator does not simply answer the questions though, he or she encourages the learner to think beyond the question and find the answer through self thought and dialogue with others. In the constructivist approach, the instructor's objective is also to prepare the information for the level of current understanding of the learner. In fact the learner is of utmost importance. In constructivism, the learner guides the lesson and the educator analyses and realizes the individuality of each learner and so tailors their lesson to best reach them.

Crawford (2001) wrote, there are five key elements to actively engaging learner in a constructivist approach to teaching. These five basic elements are:

(1) Relating: Learning in the context of one's life experiences or preexisting knowledge;
(2) Experiencing: Learning by doing, or through exploration, discovery, and invention;
(3) Applying: Learning by putting the concepts to use;
(4) Cooperating: Learning in the context of sharing, responding, and communicating with others
(5) Transferring: Using knowledge in a new context or novel situation; one that has not been covered in class.

Kelley and Kellam (2009) have attempted to provide a philosophical framework for technology education that embraces new philosophies of learning and thinking (constructivism, engineering design, and systems thinking). If technology educators determine that their purpose is to help prepare farmers to live and work in this global society, then these educators should consider carefully defining a philosophical framework upon which to build a new curriculum. The authors wish for technology educators to consider the proposed framework as a foundation for technology education as it has much promise in preparing farmers to function in today's technological society.

Bawden (1991) wrote the systemic paradigm calls for us to rethink our views of our world. If this rethinking is to lead to the sort of innovative and regenerative processes leading to large-scale improvements in the quality of relationships between people and their environments, it must come from a belief that new ways are crucial to produce new knowledge. As agricultural scientists, we must be prepared to question critically our beliefs about what we really think constitutes improvements to agriculture. We must also be prepared to enter into debates about what should be as well as creating visions about what could be. Our focus must extend beyond what is effective and efficient to embrace the ethical. We must be prepared to state what we think is good and what we think is bad, and we certainly must be ready to discuss what is aesthetically acceptable and what is not.

The key elements of systems thinking in farming systems include a holistic approach, orientation towards the needs of defined target groups, high levels of farmer participation and hence co-learning by farmers and specialists. It is now widely acknowledged that the farming systems research approach has made significant contributions to the improvement of agricultural research and education systems throughout the World (Collinson, 2000).

Based on different researchers (Kelley and Kellam, 2009; Dearing and Daugherty, 2004; Crawford, 2001; Bawden, 1991), the main factors that affected on technology education, is expressed in Figure 1.

MATERIALS AND METHODS

The method of research was correlative descriptive and causal relation. A random sample of agricultural extension educators of Khouzestan province, Iran (n=105) were selected for participation in the study. A questionnaire was developed to gather information regarding reengineering in agricultural technology education.

Questions were generated from the literature review. The survey was divided into two sections to gather data on personal characteristics of extension educators and the degree of current and favorable regarding agricultural technology education based on constructivism, engineering design and systems thinking from extension educators' perspective. Responses for 2nd section were categorized using a Likert-type scale from point 1 to 5 representing very low important to very high important respectively. Content and face validity were established by a panel of experts from faculty members. Questionnaire reliability was estimated by calculating Cronbach's alpha. Reliability was Cronbach's alpha=0.85. Data collected were analyzed using the Statistical Package for the Social Sciences (SPSS). Appropriate statistical procedures for description (frequencies, percent, means, and standard deviations) were used.

RESULTS AND DISCUSSION

Reengineering agricultural technology education based on constructivism

Based on agricultural extension educators' perception, current and favorable conditions regarding agricultural technology education based on constructivism were analyzed. Based on the results that were explained in Table 1, current condition regarding all items of technology education based on constructivism is not favorable. Prioritization is based on the coefficient of variation (CV). The coefficient of variation is less about any subject; this subject is a higher priority. The top six ranked items in favorable conditions were: (1) Emphasizing discourse and collaboration (M=4.67, Sd=0.89), (2) Ability to communicate ideas (M=3.98, Sd=0.78); (3) Developing self thought and reliance (M=4.42, Sd=0.89); (4) Discover knowledge through group work (M=4.56, Sd=0.96); (5) Programs place a high value on field work (M=4.71, Sd=1.06), and (6)

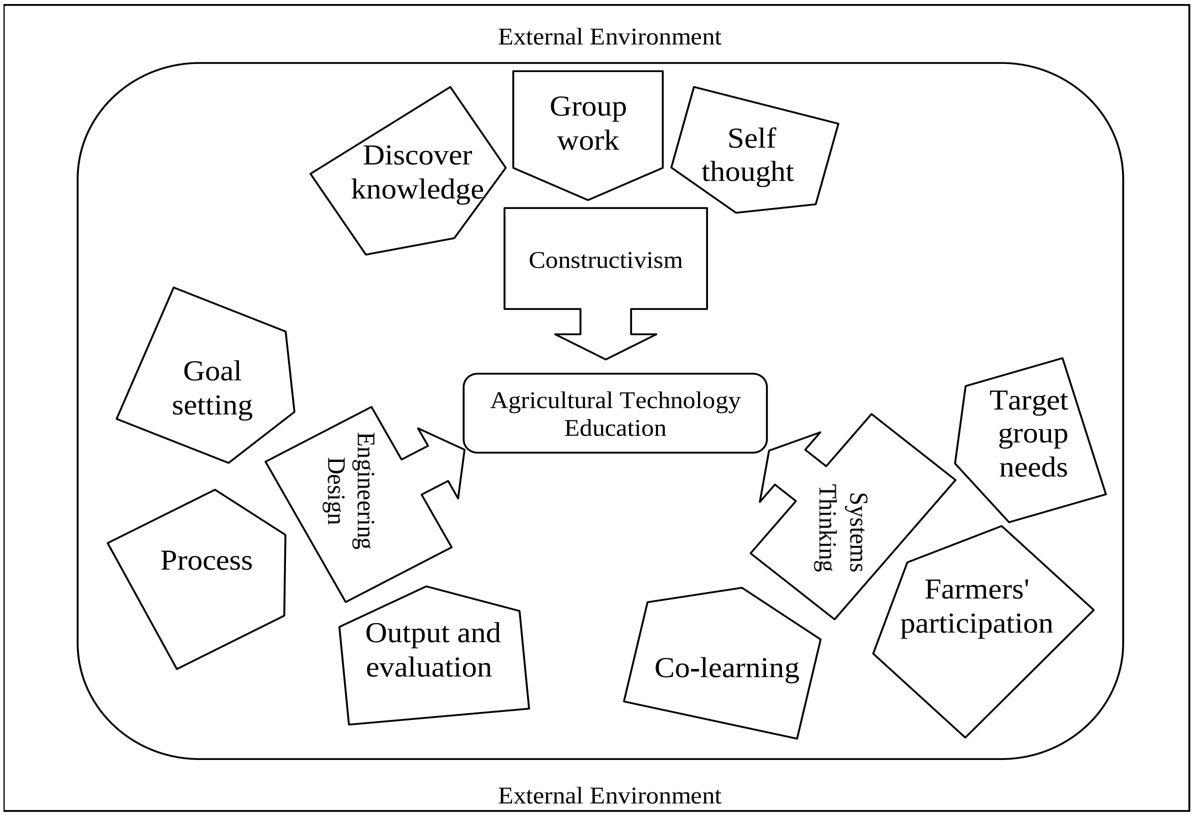

Figure 1. Conceptual framework of research.

Table 1. Reengineering agricultural technology education based on constructivism.

Items	Current condition		Favorable condition*		CV[a] of FC[b]	Priority
	Mean	Sd	Mean	Sd		
Emphasizes discourse and collaboration	2.65	1.05	4.67	0.89	0.19	1
Ability to communicate ideas	2.46	1.03	3.98	0.78	0.20	2
Developing self thought and reliance	2.65	0.91	4.42	0.89	0.20	3
Discover knowledge through group work	2.34	0.94	4.56	0.96	0.21	4
Programs place a high value on field work	2.88	0.99	4.71	1.06	0.23	5
Using problem solving methods	2.54	1.09	4.67	1.09	0.23	6
Learner Is of utmost importance	2.65	0.90	3.98	0.90	0.23	7
Role of teacher is a guide, facilitator and co-explorer	2.81	0.98	4.23	0.99	0.23	8
Developing teamwork practices	2.23	0.98	4.09	0.98	0.24	9
Self-Direction, self-monitoring, self-assessment to engage learners on a personal level	2.55	0.93	4.44	1.07	0.24	10
Learners can learn how to understand other’s opinions	2.76	0.91	4.06	0.98	0.24	11
Information seeking by farmers	2.21	0.92	4.02	0.98	0.24	12
Promote learner-centered instruction	2.34	1.09	4.06	0.99	0.24	13
Programs include opportunities for reflection about the various discussions, and experiences	3.08	0.96	4.10	1.03	0.25	14
Goal of education Is HRD	2.76	1.06	3.89	1.01	0.26	15
Using visual techniques for education	2.45	1.08	4.09	1.08	0.26	16
Using action research in technology education	2.12	0.93	4.09	1.09	0.27	17

5, Very high important; 1, very low important; *must be considered; [a]*Coefficient* of variation; [b]Favorable condition.

Table 2. Causal comparative between current and favorable conditions in agricultural technology education based on constructivism by Wilcoxon signed ranks.

Items	Z	Sig
Developing teamwork practices	10.100	0.000**
Ability to communicate ideas	10.247	0.000**
Using problem solving methods	11.314	0.000**
Developing self thought and reliance	9.450	0.000**
Information seeking by farmers	10.154	0.000**
Discover knowledge through group work	11.091	0.000**
Learner is of utmost importance	9.892	0.000**
Using visual techniques for education	10.128	0.000**
Goal of education is HRD	9.098	0.000**
Promote learner-centered instruction	10.540	0.000**
Emphasizes Discourse and Collaboration	10.671	0.000**
Programs place a high value on field work	11.092	0.000**
Using action research in technology education	11.231	0.000**
Learners can learn how to understand other's opinions	10.923	0.000**
Role of teacher is a guide, facilitator, and co-explorer	10.491	0.000**
Self-direction, self-monitoring, self-assessment to engage learners on a personal level	10.991	0.000**
Programs include opportunities for reflection about the various discussions, and experiences.	3.890	0.020*

*P≤0.05, **P≤0.01.

Table 3. Causal comparative between overall items of constructivism education in current and favorable conditions by Wilcoxon signed ranks.

Item	Z	Sig
Overall items of constructivism education	14.100	0.000**

*P≤0.05, **P≤0.01.

Using problem solving methods (M=4.67, Sd=1.09).

In inferential analysis, Wilcoxon signed ranks were used for analyzing causal comparative of educational constructivism elements in agriculture between current and favorable conditions. Based on the results of Tables 2 and 3 in each and overall items (Z=14.100, P=0.000) there were significant differences between current and favorable conditions. Thus, there must be providing condition to development constructivism education. It is a learning or meaning-making theory which offers an explanation of the nature of knowledge and how human beings learn.

Knowledge is obtained by participating in content instead of imitation or repetition. Learning activities in constructivist settings are characterized by active engagement, inquiry, problem solving, and collaboration with others. The role of educator is a guide, facilitator, and co-explorer who encourages learners to question, challenge, and formulate their own ideas, opinions, and conclusions rather than a distributor of knowledge (Flynn,2006; Dangel and Guyton, 2004).

Reengineering agricultural technology education based on systems thinking

Based on agricultural extension educators' perception, current and favorable conditions regarding agricultural technology education based on systems thinking were analyzed. Based on the results that were explained in Table 4, also current condition regarding all items of technology education based on systems thinking is not favorable. The top six ranked items in favorable conditions were: (1) Focus on the needs of farmers (M=4.92, Sd=0.84); (2) Negotiating assessment processes (M=4.89, Sd=0.98); (3) Considering farm as system (M=4.69, Sd=0.90); (4) Need for a more holistic understanding (M=4.50, Sd=0.93); (5) Helping learners confront personal beliefs and create their own theories of learning (M=4.94, Sd=1.09), and (6) Providing learners with opportunities to examine, analyze, and reflect on their own thinking (M=3.94, Sd=0.96).

In inferential analysis, Wilcoxon signed ranks was used for analyzing causal comparative of systems thinking

Table 4. Reengineering Agricultural Technology Education Based on Systems Thinking.

Items	Current condition		Favorable condition*		CV of FC	Priority
	Mean	Sd	Mean	Sd		
Focus on the needs of farmers	2.89	1.10	4.92	0.84	0.17	1
Negotiating assessment processes	2.03	1.09	4.89	0.93	0.19	2
Considering farm as system	3.89	0.77	4.69	0.90	0.19	3
Need for a more holistic understanding	3.08	0.84	4.50	0.93	0.21	4
Helping learners confront personal beliefs and create their own theories of learning	3.10	0.91	4.94	1.09	0.22	5
\Providing learners with opportunities to examine, analyze, and reflect on their own thinking	2.94	0.83	3.94	0.96	0.24	6
Encouraging learners to self-assess, learning from their successes and mistakes	3.43	0.67	4.08	1.01	0.25	7
Emphasis on continuous evaluation	2.95	0.77	3.89	1.03	0.26	8
Participatory learning between farmers	2.09	0.97	4.02	1.09	0.27	9
Co-learning by farmers and specialists	3.08	1.11	3.90	1.30	0.33	10
Orientation towards the needs of defined target groups	2.79	1.02	4.09	1.83	0.45	11
High levels of farmer participation	2.99	0.98	4.37	1.97	0.45	12

5, Very high important; 1, very low important; *, must be considered.

Table 5. Causal comparative between current and favorable conditions in agricultural technology education based on systems thinking by Wilcoxon signed ranks.

Item	Z	Sig
Orientation towards the needs of defined target groups	11.902	0.000**
High levels of farmer participation	10.095	0.000**
Co-learning by farmers and specialists	4.901	0.018*
Emphasis on continuous evaluation	8.092	0.000**
Participatory learning between farmers	9.893	0.000**
Negotiating assessment processes	10.430	0.000**
Focus on the needs of farmers	9.682	0.000**
Considering farm as system	8.092	0.000**
Need for a more holistic understanding	5.904	0.021*
Providing learners with opportunities to examine, analyze, and reflect on their own thinking	10.093	0.000**
Helping learners confront personal beliefs and create their own theories of learning	11.009	0.000**
Encouraging learners to self-assess, learning from their successes and mistakes	4.676	0.014*

*P≤0.05, **P≤0.01.

elements in agriculture between current and favorable conditions. Based on the results in each (Table 5) and overall (Table 6) items (Z=12.159, P=0.000) there were significant differences between current and favorable conditions. The key elements of farming systems thinking include a holistic approach, orientation towards the needs of defined target groups, high levels of farmer participation and hence co-learning by farmers and specialists (Petheram and Clark, 1998). Different researches such as Collinson (2000) stated that the farming systems approach has made significant contributions to the improvement of agricultural research and education systems throughout the World.

Reengineering agricultural technology education based on engineering design

Also current and favorable conditions regarding agricultural technology education based on engineering design were analyzed. Based on the results that were explained in Table 7 current condition regarding all items

Table 6. Causal comparative between overall items of systems thinking in current and favorable conditions by wilcoxon signed ranks.

Item	Z	Sig
Overall items of constructivism education	12.159	0.000**

*P≤0.05, **P≤0.01.

Table 7. Reengineering agricultural technology education based on engineering design.

Items	Current condition		Favorable condition*		CV of FC	Priority
	Mean	Sd	Mean	Sd		
Communication and analytical skills	2.98	0.84	4.49	0.68	0.15	1
Interpersonal skills: teamwork, group skills, attitude, and work ethic	3.01	0.97	3.99	0.76	0.19	2
Problem-solving and creative thinking	3.08	1.09	4.91	0.96	0.20	3
Formative evaluation	3.34	0.82	4.69	1.03	0.22	4
Contributions from both social and natural science in the educational process	2.49	0.91	4.20	0.93	0.22	5
The ability to negotiate and influence, and self-management	3.11	1.11	4.95	1.14	0.23	6
Ability to communicate ideas: verbally, physically, and visually	2.92	1.09	4.03	0.94	0.23	7
Product design assessment	2.09	0.93	3.92	0.92	0.23	8
Summative evaluation	3.01	0.93	4.29	1.12	0.26	9
Participation of farmers in goal setting	3.02	1.04	3.98	1.09	0.27	10
Using engineering participatory methods in need assessment	3.04	1.01	4.01	1.12	0.28	11
Experience in brainstorming and generating ideas	2.95	0.99	**3**.49	1.03	0.30	12

5, Very high important; 1, very low important; *, must be considered.

of technology education based on engineering design is not favorable. The top six ranked items in favorable conditions were: (1) Communication and analytical skills (M=4.49, Sd=0.68); (2) Interpersonal skills: Teamwork, group skills, attitude, and work ethic (M=3.99, Sd=0.76); (3) Problem-solving and creative thinking (M=4.91, Sd=0.96); (4) Formative evaluation (M=4.69, Sd=1.03); (5) Contributions from both social and natural science in the educational process (M=4.20, Sd=0.93), and (6) The ability to negotiate and influence, and self-management (M=4.95, Sd=1.14).

In inferential analysis, Wilcoxon signed ranks were used for analyzing causal comparative of engineering design elements in agriculture between current and favorable conditions. Based on the results in each (Table 8) and overall (Table 9) items (Z=12.159, P=0.000), there were significant differences between current and favorable conditions. Multiple researchers such as Kelley and Kellam (2009) and Daugherty (2005) pointed out, engineering design for addressing the standards for technological literacy, creating a new model that attracts and motivates learner from all literacy levels. Today's job forces require a set of skills. These include communication skills, analytical skills, problem-solving and creative thinking, interpersonal skills, the ability to negotiate and influence, and self-management (Kelley and Kellam, 2009).

CONCLUSIONS AND RECOMMENDATION

The key elements which need to be incorporated into a new approach to technology education in farming systems are: Constructivism (constructivist design is a professional model that responds to the call for "new philosophy model of agricultural education" that emphasize learner centered strategies), systemic thinking (the need for a more holistic understanding of the context of farming and rural livelihoods), engineering design (the active participation and partnership of farmers and other key stakeholders in the process of design, planning, implementing, monitoring and evaluating research and communication skills, analytical skills, problem-solving and creative thinking, interpersonal skills, the ability to negotiate and influence, and self-management). By incorporating these principles, we can provide appropriate condition for technology education and diffusion. In this article, the author has attempted to reengineer technology education based on constructivism, engineering design, and systems thinking in farming

Table 8. Causal comparative between current and favorable conditions in agricultural technology education based on engineering design by Wilcoxon signed ranks.

Item	Z	Sig
Using engineering participatory methods in need assessment	10.443	0.000**
Participation of farmers in goal setting	10.434	0.000**
Experience in brainstorming and generating ideas	3.455	0.035*
Product design assessment	12.453	0.000**
communication and analytical skills	10.554	0.000**
problem-solving and creative thinking	8.094	0.000**
The ability to negotiate and influence, and self-management	9.763	0.000**
Formative evaluation	10.881	0.000**
Summative evaluation	10.554	0.021*
Contributions from both social and natural science in the educational process	8.986	0.000**
Interpersonal skills: teamwork, group skills, attitude, and work ethic	9.776	0.000**
Ability to communicate ideas: verbally, physically, and visually	10.566	0.000**

*P≤0.05, **P≤0.01.

Table 9. Causal comparative between overall items of engineering design in current and favorable conditions by Wilcoxon signed ranks.

Item	Z	Sig
Overall items of constructivism education	13.901	0.000**

*P≤0.05, **P≤0.01.

systems and provide a philosophical framework for technology education that holds true to adult education approaches that are at the heart of the success of technology education in farming systems.

Based on the results, current condition regarding all items of technology education based on constructivism is not favorable. The top six ranked items in favorable conditions were: (1) Emphasizing discourse and collaboration; (2) Ability to communicate ideas; (3) Developing self thought and reliance; (4) Discovering knowledge through group work; (5) Programs place a high value on field work, and 6) Using problem solving methods.

Also current condition regarding all items of technology education based on systems thinking is not favorable. The top six ranked items in favorable conditions were: (1) Focusing on the needs of farmers; (2) Negotiating assessment processes; (3) Considering farm as system; (4) Need for a more holistic understanding; (5) Helping learners confront personal beliefs and create their own theories of learning, and (6) Providing learners with opportunities to examine, analyze, and reflect on their own thinking.

In addition, current condition regarding all items of technology education based on engineering design is not favorable. The top six ranked items in favorable conditions were: (1) Communication and analytical skills; (2) Interpersonal skills: Teamwork, group skills, attitude, and work ethic; (3) Problem-solving and creative thinking; (4) Formative evaluation; (5) Contributions from both social and natural science in the educational process, and (6) The ability to negotiate and influence, and self-management.

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