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An Analysis of Effectiveness of Programmed Instruction on Cognitive Domain of Extension Functionaries in Karnataka, India

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Abstract
With a view to explore the potentiality of Programmed Instruction (PI) as an educational method in bringing desirable changes in the cognitive domain of extension functionaries on new agriculture technology, this experimental study was conducted using Solomon four group design: before-after with three controls considering 120 respondents. The results revealed that, the mean effectiveness scores among the sub domains of cognitive domain was higher in evaluation sub domain (52.33) followed by synthesis (48.17), knowledge (47.83), analysis (47.00), comprehension (38.50) and application (37.17). The overall effectiveness score of cognitive domain was 45.17 signifying that, the PI is an effective educational method.

Keywords
Programmed instruction, Cognitive domain, sub-domain

I. Introduction

The Programmed Instruction (PI) is a self instructional method in which, new subject matter is presented to the learners in a graded sequence of controlled steps. Here, the learners work through the PI by themselves at their own speed and after each step test their learning by answering a question as well, they can find the correct answer immediately[1]. The PI is a learning methodology proposed by the behaviourist Skinner[2] based on his theory, Operant Conditioning which states that learning occurs when a reinforcing stimulus is presented to reward a correct response. Skinner believed that humans are naturally curious and that correct responses serve as the reinforcement. In PI, subject intended to teach is presented in smaller units called frames. Each frame contains part of information followed by the question/s related to the information provided in that frame. The learner has to answer the question/s before moving on to the next frame. The next frame contains the answer for the previous frame; part of the continued information; and the questions related to that frame. The learner has to answer the question/s and move on to the next frame and the process continues till the last frame. By this stage, learner would have learnt and understood the subject which was intended to teach. The speed of learning depends on the ability of the learner.

There were very few attempts made to utilize this method by the agricultural extension functionaries to educate the farming communities in the past. Owing to its efficiency and effectiveness in different fields of education, an experimental study was conducted to explore its potential to bring desirable changes in the cognitive domain of extension functionaries.

The cognitive domain[3] involves knowledge and development of intellectual skills. This includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills. There are six sub-domains of the cognitive domain, namely, (a) knowledge, (b) comprehension, (c) application, (d) analysis, (e) synthesis, and (f) evaluation. It moves from the simplest behaviour to the most complex. In other words, these categories can be thought of as degrees of difficulties meaning, first ones must normally be mastered before the next ones can take place.

Knowledge refers to the ability of the learner to recall data or information; comprehension is the ability of the learner to understand the meaning, translation, and interpretation of information and instructions; application refers to the ability of the learner to use a concept in a new situation; analysis is the ability of the learner to separate material or concepts into component parts so that its organizational structure may be understood; synthesis refers to the ability of the learner to build a structure or pattern from diverse elements; evaluation refers to the ability of the learner to make judgments about the value of ideas or material.

The uniqueness of the present study is that, sensitiveness of PI in influencing the changes under different sub-domains of cognitive domain was quantified for its effectiveness.

II. Material aAnd Methods

The experiment was conducted in the Staff Training Unit of University of Agricultural Sciences, Bengaluru during trainings organised to Extension Functionaries *viz*., Agricultural Officers (AOs) / Assistant Agricultural Officers (AAOs) of the Karnataka State Department of Agriculture (KSDA), India, during 2013-14. The research design used was Solomon four group experimental design: before-after with three controls. The sample consisted of four groups with 30 extension functionaries in each group and hence, a total of 120 extension functionaries constituted the sample respondents for the study.

In the present investigation, the PI material was developed using the linear method of programming on the contemporary subject-climate change, its impact, mitigation and adaptation strategies in agriculture. The developed PI material consisted of 65 frames which was got printed into a booklet form of size 21.5cm X 13.5cm dimension. The readability of PI material was found to be at IX grade indicating that the persons with ninth standard and above can easily read and understand.

In the process of measuring the changes in the cognitive domain, a scale was developed and standardised. The scale consisted of five items to measure each of the six sub domains of cognitive domain and thus, overall, scale contained 30 items.

During the experimentation, as per the research design requirement, as a first step, the participants were given orientation on the purpose, method and expected action from the respondents. Secondly, pre testing was done to two groups (G_1 and G_2). Thirdly, standardised PI material was given to two groups (G_1 and G_3) to go through the material and complete the process. As a fourth step, post test was conducted for all the four groups using the standardised scale. The details of experimentation are given in Table 1.

Table 1: Experiment to assess the effect of programmed instruction

Group/ batch	*No. of respondents*	*Pre test (Y_b)*	*Stimulus/ treatment (X)*	*Post test (Y_a)*
G_1	30	Yes	Programmed instruction	Yes
G_2	30	Yes	No	Yes
G_3	30	No	Programmed instruction	Yes
G_4	30	No	No	Yes

The effect of stimulus / treatment (X) was worked out using the following formula.

$d_1 = (Ya–Yb)G_1 – (Ya–Yb)G_2$ (gives stimulus effect + Sensitizing effect)

$d_2 = (Ya – Yb)G_1 –(Ya – Yb)G_3$ (gives sensitizing effect)

$Z_1 = (d_1 – d_2)$ (gives stimulus effect)

$Z_2 = (Ya)G_3 – (Ya)G_4$ (gives stimulus effect)

$$\textit{Stimulus effect (X)} = \frac{Z_1 + Z_2}{2}$$

The quantification of effectiveness of stimulus on cognitive domain was worked out using the following formula.

$$ECD = \sum_{n=1}^{5}\frac{AKS}{PKS}X100 + \sum_{n=1}^{5}\frac{ACS}{PCS}X100 + \sum_{n=1}^{5}\frac{AApS}{PApS}X100 + \sum_{n=1}^{5}\frac{AAnS}{PAnS}X100 + \sum_{n=1}^{5}\frac{ASS}{PSS}X100 + \sum_{n=1}^{5}\frac{AES}{PES}X100$$

Where,

d_1 = difference 1

d_2 = difference 2

Y_a = observations recorded after the treatment

Y_b = observations recorded before the treatment

G_1, G_2, G_3 and G_4 = 1st, 2nd, 3rd and 4th Groups respectively

Z_1 = Stimulus effect 1

Z_2 = Stimulus effect 2

The quantification of effectiveness of stimulus on cognitive domain was worked out using the following formula.

Where,

ECD = Effectiveness of stimulus on cognitive domain
AKS = Actual knowledge score
PKS = Possible knowledge score
ACS = Actual comprehension score
PCS = Possible comprehension score
AApS = Actual application score
PApS = Possible application score
AAnS = Actual analysis score
PAnS = Possible analysis score
ASS = Actual synthesis score
PSS = Possible synthesis score
AES = Actual evaluation score
PES = Possible evaluation score

III. Results and Discussion

The results presented in Table 2 indicate the effectiveness of stimulus (the true effect of PI after eliminating the sensitisation effect due to pre test, checking the uncontrolled and other natural causes of influences on the respondents) on different dimensions of cognitive domain of the extension functionaries. It could be seen from the table that, PI had sizeable influence on cognitive domain (45.17) in learning about the climate change subject. Further, the mean effectiveness scores of PI in different sub-domains of cognitive domain ranged from 37.17 to 52.33 indicating substantial influence of PI in all the sub-domains of cognitive domain. However, it was found to be more effective in the evaluation sub-domain (52.33) followed by synthesis, knowledge, analysis, comprehension and application (37.17). The data on this table have been illustrated in Figure 1.

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Table 2: Effectiveness of PI on cognitive domain of extension functionaries

(Mean scores)

Particular	*Cognitive domain*	*Sub-domains of the cognitive domain*					
		Know-ledge	*Compre-hension*	*Appli-cation*	*Ana-lysis*	*Syn-thesis*	*Eva-luation*
G_1: Pre test (Y_b)	17.33	13.00	23.00	22.67	13.67	18.33	13.33
G_1: PI + Post test (Y_a)	93.06	97.67	92.67	91.67	91.67	91.33	93.33
G_2:Pre test (Y_b)	17.39	12.67	20.67	24.33	12.00	24.67	10.00
G_2: Post test (Y_a)	23.22	16.00	27.33	22.67	20.67	31.33	21.33
G_3:PI + Post test (Y_a)	57.06	57.33	51.00	48.00	60.00	62.67	63.33
G_4: Post test (Y_a)	17.94	15.67	18.33	23.33	17.33	22.33	10.67
$d_1 = (Y_a-Y_b)G_1 - (Y_a-Y_b)G_2$	69.89	81.33	63.00	70.67	69.33	66.33	68.67
$d_2 = (Y_a-Y_b)G_1 - (Y_a-Y_b)G_3$	18.67	27.33	18.67	21.00	18.00	10.33	16.67
$Z_1 = d_1-d_2$	51.22	54.00	44.33	49.67	51.33	56.00	52.00
$Z_2 = (Y_a-Y_b)G_3 - (Y_a-Y_b)G_4$	39.11	41.67	32.67	24.67	42.67	40.33	52.67
Stimulus (PI) effect $= Z_1+Z_2/2$	45.17	47.83	38.50	37.17	47.00	48.17	52.33

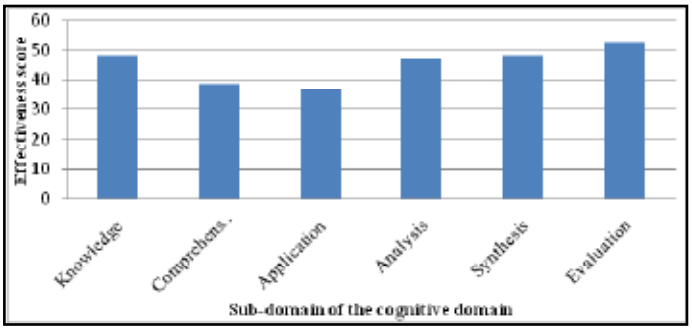

Fig. 1: Effectiveness of PI on sub-domains of cognitive domain of extension functionaries

The PI method has several advantages over conventional methods *viz*., (a) provides positive reinforcement in a contingent manner on the accomplishment of each step, (b) has built in mechanism of self instruction and self testing, (c) coherence of the programme-mastering step by step, (d) immediate knowledge of the results, (e) increased probability of answering correctly, (f) the learning rate depends on the learners capabilities, (g) suitable for all categories of learners, (h) has no spatial restriction.

There are several classical theories that support to prove the effectiveness of PI in learning. Important ones are (a) cognitive load theory[4] which states that working memory load should be reduced in order to facilitate the changes in long term memory associated with schema acquisition; (b) component display theory[5] states that a complete lesson with objectives followed by combination of rules, examples, recall, practice, feedback, helps in understanding the subject; (c) theory of conditions of learning[6] suggests that learning tasks for intellectual skills can be organized in a hierarchy according to complexity: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving. The primary significance of the hierarchy is to identify prerequisites that should be completed to facilitate learning at each level; (d) connectionism theory[7] explains that, connections are more readily established if the person perceives that stimuli or responses go together; (e) constructivist theory[8] states that a theory of instruction should address four major aspects *viz*., predisposition towards learning, the ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner, the most effective sequences in which to present material, and the nature and pacing of rewards and punishments; (f) theory of criterion referenced instruction[9] states that comprehensive instructional frame work with criterion reference would bring out specified outcomes; (g) minimalism theory[10] suggests that all learning tasks should be meaningful and self-contained activities, learners should be given realistic projects as quickly as possible, instruction should permit self-directed reasoning and improvising by increasing the number of active learning activities, training materials and activities should provide for error recognition and recovery and, there should be a close linkage between the training and actual system; (h) theory of modes of learning[11] proposed that there are three modes of learning: accretion, structuring and tuning. Accretion is the addition of new knowledge to existing memory. Structuring involves the formation of new conceptual structures or schema. Tuning is the adjustment of knowledge to a specific task usually through practice; (i) repair theory[12] imply that problem sets should be chosen to eliminate the bias likely to cause specific mistakes and mistakes are often introduced when students try to extend procedures beyond the initial examples provided; (j) script theory[13] indicate that events are understood in terms of scripts, plans and other knowledge structures as well as relevant previous experiences.

If we look at the actual effect of PI in acquisition of technology on climate change by the extension functionaries at different components of cognitive domain, it was significant but the effect ranged from 37.17 to 52.33. The findings are discussed for each sub-domain of cognitive domain in the following paragraphs.

Acquisition of *knowledge* is considered as the first sub-domain which refers to the ability of the learner to recall data or information. The recall behaviour in human beings can be better explained by relating schema theory[14]. This theory indicates that human beings develop large network of knowledge structures or schemas, with each schema connected to many others. These schemas grow and change as a person acquires new information through experience and reading. The term schema can be defined as a kind of storage cabinet in human brains with file folders containing different information about concepts, events, emotions and roles drawn from life experiences. Each schema is connected to other related

schemas, forming a vast interconnected network of knowledge and experiences. The PI material has helped the extension functionaries to develop knowledge structures or schemas relating to climate change and other related issues and thus, the actual effect of PI was significant (47.83).

Comprehension has been the second sub-domain considered in the cognitive domain. The comprehension refers to the ability of the learner to understand the meaning, translation, and interpretation of information and instructions. The functional context approach to learning[15] stresses the importance of making learning more meaningful, relevant to the learners and their work context, which help them to translate old knowledge into new knowledge and interpret the knowledge as per their need. The PI material has provided a meaningful learning environment for the learners who were on the job and thus, significant effect of PI was observed in comprehension of the technology (38.50).

The third sub-domain in cognitive domain was the *Application*. Application refers to the ability of the learner to use a concept in a new situation. Genetic Epistemology theory[16] suggests that cognitive structures change through the process of adaptation, assimilation and accommodation. Assimilation involves the interpretation of events in terms of existing cognitive structure whereas, accommodation refers to changing the cognitive structure to make sense of the environment. Cognitive development consists of a constant effort to adapt to the environment in terms of assimilation and accommodation. There was a scope for the extension functionaries for application of concepts learnt through exposure to PI (37.17) as the content was relevant to the emerging environmental issues.

Analysis is the ability of the learner to separate material or concepts into component parts so that its organizational structure may be understood. This was the fourth sub-domain. The importance of this domain in learning can be related to Transformative learning theory[17] which describes that the learner interpret and reinterpret the things learnt to separate concepts into component parts and referred it as constructivist behaviour. Thus, the PI has provided scope for extension functionaries to get existing information clarified by examining parts and relationships as well as, identifying attributes and components to determine the characteristics or the parts of climate change (47.00). Further, it was also possible to identify the relationships and patterns of different components of the technology.

The fifth sub-domain was *synthesis*. This refers to the ability of the learner to build a structure or pattern from diverse elements. Constructivist theory[8] states that learning as an active process in which learners construct new ideas or concepts based upon their current/ past knowledge. The learner selects and transforms information, constructs hypothesis, and makes decisions, relying on cognitive structures to do so. Cognitive structure provides meaning and organisation to experiences and allows the individual to go beyond the information given. Thus it is justifiable for inclusion of synthesis as a sub-domain in the cognitive domain. The PI had considerable influence (48.17) on synthesising the climate change technology at this sub-domain.

Evaluation refers to the ability of the learner to make judgments about the value of ideas or material. This is the sixth sub-domain of the cognitive domain. This is the important component of learning. Even the cognitive behavioural theory[18] supports the relevance of evaluation in learning which says that individuals tend to form self concepts that affect the behaviour they display. These concepts can be positive or negative and can be affected by a person's environment. The PI had highest influence in this sub-domain compared to other sub-domains (52.33) which may be due to the fact that, the PI could provide an opportunity for extension functionaries to assess the reasonableness and quality of ideas, establishing criteria by setting standards for making judgments and verifying by confirming the accuracy of claims.

IV. Conclusion

The PI demonstrated positive and significant effect on the cognitive domain of extension functionaries on the subject - climate change, its impact, mitigation and adaptation strategies in agriculture. Further, PI was found to be effective at all the sub-domains of cognitive domains in acquiring new technology. Therefore, the PI material can be best utilised to educate extension functionaries on the new agricultural technologies emerging from time to time. PI can also be used for modifying the intellectual abilities and skills of the literate farmers on new agricultural technologies like protected cultivation, secondary agriculture *etc*., which intern drive them towards adoption of these technologies.

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