How the 'Productive Failure' Instructional Design Encapsulates the 'Active Learning' Essence of Eliciting L2 Output Using the 'Information Gap' Construct

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Abstract
'Productive failure' (Kapur, 2010) is an instructional design based on the contrast between learners' intuitive assumptions and proven solutions to problems analyzed for educational purposes in a given discipline. This design involves learners attempting creation of solutions before being taught, which is thought to enhance learning in that it prepares learners to comprehend taught content more solidly, even if their initial assumptions were incorrect, or a 'failure'. Much of the research and experimentation regarding this takes place in contexts outside of language learning, yet the productive failure design and related designs fall under the broader heading of active learning, something the Ministry of Education in Japan has been increasingly attuned to in recent policy developments (McMurray, 2018). Intriguingly, it is evident that much of what is described as the learning processes and effects of productive failure closely resembles what is described in literature on L2 output production during communicative interaction and associated opportunities for language acquisition. Parallels between the active learning aspects of productive failure and processes involved in authentic output production is portrayed and explained in this paper. The concept behind information gap activities, with one interlocutor having the answer and the other deducing it from contextual clues and attempting to express it accurately, can be used to elicit output and negotiation of meaning in ways that operate and potentially develop learners' linguistic resources. How information gaps can be made to function this way, incorporating a form of active learning similar to productive failure, is exemplified and discussed.

Keywords: information gaps; L2 output; active learning

Introduction

The 'information gap' is a construct used in language education that is based on, in principle, a gap in what is known to different participants in a communicative situation. This is useful in the language classroom in that students can try using the target language to exchange this information amongst each other or with their teacher, and the nature and complexity of language necessary to do this can be controlled, to certain extents, by the content, design and parameters of an activity. Drawing on this concept, real communication could be thought of as always involving a gap, and this gap is what generates the very need to communicate. In this sense, it is important to consider the ways that gaps can be incorporated into classroom activities to elicit use of the target language. This paper discusses a particular structure of information gap activity designed for English communication classes for university students in Japan. In general, this structure involves one member of a group knowing the answer, and other members *guessing* the content of the gap through inferences or assumptions as opposed to directly asking for and being told the information. This means that the extent to which learners need to decide the linguistic structure and content of their guesses on their own can vary according to activity parameters and the size of the gap. Thus, they must apply their own linguistic resources to formulate utterances that a gap elicits. Depending on the complexity of the content and what kind of guess the gap prompts, the required structural and lexical complexity of learner output can be roughly predicted. Attempting to communicate at this level of precision, the learner may exhibit misconceptions of target language usage or lack linguistic resources. The learner may then have to re-attempt formulations of their message to make them comprehensible to their interlocutor, conjuring up and applying various representations of language knowledge existing in their mind. They may also draw conclusions collectively with peers on semantic accuracy and appropriate form. The 'answer' holder is also in the position to provide corrective feedback on peer utterances by comparing them with the original content from the gap, providing hints to steer their peers towards producing a legitimate rendition of the answer.

According to discussions in the literature of possible effects of producing L2 output in communicative situations, all of the processes described above can be thought of as beneficial to language learning. Swain's (1985) output hypothesis and other studies and discussions stemming from it over the years (Swain & Lapkin, 1995; Shehadeh, 2002; Izumi, 2002,2003; Sato & Lyster, 2012) investigate how such learning benefits might occur. One of the main themes throughout output related literature is "negotiation of meaning" (Pica et al., 1989). Even the most basic information gap activities have the potential to instigate negotiation of meaning, however, the argument to be developed in this paper is that further inspection of literature on developmental learning processes can provide an informed perspective on the potential functions of information gaps in interactive language learning situations. Studies and concepts to be inspected here have been drawn from literature on a form of active learning called "productive failure" (Kapur, 2010) developed within the disciplinary context of maths and sciences education, and literature connected to the discipline of developmental psychology on how mental models develop in learning situations (Bucciarelli, 2007; Wagoner, 2011; Wagoner & Gillespie, 2014). Insights from these sources into learning processes and how to stimulate them will be portrayed in detail in this article. Similarities between what can be learned from these different disciplinary contexts will also be explained and discussed. It is the evident

links between the concepts discussed across these three disciplinary contexts that intensifies the urgency of integrating these concepts into language education programs. With the Ministry of Education in Japan focusing increasingly on 'active learning' in recent policy developments (McMurray, 2018), educators need to develop their conception of how active learning can manifest specifically for the purpose of language learning. Finally, to depict one form of such a manifestation, an example of the type of information gap activity described above will be explained as one possible way of eliciting the implied learning benefits of productive failure and pushed output in the language classroom.

How Schema Development is Thought to Work

Schema can be defined as "any macro knowledge structure encoded in memory that represents substantial knowledge about a concept, its attributes, and its relations to other concepts" (Huesmann, 1998, p. 79). Schema can be activated as a reaction to the demands of any situation requiring the application of relevant knowledge and abilities. A well-developed set of schemata of both declarative and procedural knowledge for the function and use of a target language would mark an individual's proficiency in that language. How schemata and mental models are developed and refined to the point of practical accuracy and functionality can provide insight into what is involved in effective learning. External stimuli may contradict expectations that derive from mistaken or incomplete mental representations, which can motivate modification, addition to, or re-association of relevant schema: "cognitive conflict favors the construction of alternative models of a perceived or described situation, thus favoring learning to reason" (Bucciarelli, 2007, p. 80-81). This constitutes a depiction of learning as the acknowledgement of the differences between internal models and conflicting evidence from external sources. Regarding the "productive failure" (Kapur, 2010) learning design, which is further explained in the following section, this is referred to as "differentiation", which involves the conscious contrasting of relevant and irrelevant factors in devising a solution to a problem (p. 2727), and has been found to enhance comprehension (p. 2728). The important point to be considered here in terms of educational methodology is that prior knowledge, or existing schema, play a role in the development of proficiency as they are activated and involved in the acquisition of new concepts: "The mind becomes able to exploit internally the information already stored, by re-describing its representations or, more precisely, by iteratively re-representing in different representational formats what its internal representations represent" (Bucciarelli, 2007, p. 81). An additional aspect of this that gains significance when considering educational methodology is the social nature of cognitive development. A significant source of the scaffolding required for schemata to develop is the external environment, with its culture, media tools, and social discourse, which means that incoming information and concepts have been, to some extent, developed socially before being adopted and personalized by an individual mind (Wagoner & Gillespie, 2014). If learning, then, is thought of as an adjustment of internal models in response to conflicting information, awareness of faulty elements of an internal assumption must be necessary. The interactive dynamic of learning in the presence of teachers and peers in a classroom setting provides the opportunity to engage in dialog that molds and progresses how learners might assess their own thinking to confirm or refute the appropriacy of units of knowledge. Analyzing the discourse of interlocutors collectively attempting to confirm certain memories when discussing the past, Middleton and Brown (2005) deduce that,

> a public reflection on one's own mental processes may strengthen or warrant a subsequent claim. Instead of treating conversational action as a window on mental processes, we can see that conversations act as significant environments in which thoughts are formulated, justified and socialised according to how other speakers talk about mental processes (p. 90).

This provides insight into how a group consisting of learners and instructors might collectively influence individual comprehension of targeted concepts and scaffold the development of performance of targeted skills or application of relevant methods. Educational methods can be contrived to draw learners' attention to their own preconceived assumptions and their idiosyncrasies as a means of making the meanings of features of more valid models more apparent. The key factor evident here in this is the dialogic interaction of classroom discourse as a medium for socio-cognitive activity, which will later be shown to be significant to language learning contexts in the section on output production. The following section further explains the processes involved in the productive failure learning design that resemble the psychological processes described in this section. It will be seen that productive failure, as a form of active learning (Chowrira et al., 2019), involves the design of tasks that incorporate learners' expressions of their mental processes as a way of enhancing learning.

The Reasoning Behind the Format of the 'Productive Failure' Learning Design

Kapur (2010) has thoroughly researched and developed a process for classroom learning called productive failure (PF), in which, put simply, learners make attempts at designing methods of solving a problem before being directly taught the canonical method. As a form of "extreme active learning" (Chowrira et al., 2019, p. 1), it derives from theory on knowledge development, and there are other renditions such as "invention" (Roll et al., 2011) and "prediction" (Brod et al., 2018) tasks. These designs have been empirically studied and developed in contexts such as maths, sciences and geography, yet the structure and cognitive effects to be portrayed in this section will be associated with concepts from literature on language learning in the following section.

Productive failure involves "a generation and exploration phase followed by a direct instruction phase" (Kapur, 2010, p. 2727). The idea is to engage students in "processes that serve two critical cognitive functions, … a) activating and differentiating prior knowledge in relation to the targeted concepts, and b) affording attention to critical features of the targeted concepts." (p. 2727). Teachers can give students a problem based on a novel concept but withhold instruction of the canonical formulas or methods for solving it, having the students apply their background knowledge in the subject area to design their own methods, which may be imperfect or even mistaken. Students are then directly taught the canonical method and given the opportunity to relate or differentiate features of their preconceived methods with it. Kapur (2010) explains the effects of this:

> The expectation for the generation and exploration phase is not for students to be able to solve the problem successfully. Instead, it is to generate and explore the affordances and constraints of a diversity of structures for solving the problem. To the extent that students can persist in this process, the process

> not only activates but also differentiates their prior knowledge. … Furthermore, a comparison and contrast between the various structures also affords opportunities to attend to critical features of the targeted concepts. … Consequently, the generation and exploration phase provides the necessary foundation for developing deeper understanding of the canonical concepts, representations, and methods during direct instruction. (p. 2728)

Analyses of learners undergoing PF tasks revealed that the above effects are evident in the way students went about solving problems (p. 2731). Involving prior knowledge in the learning process in this way seems to help learners understand the reasoning behind the form of the canonical method more deeply, allowing them to grasp and apply necessary concepts more effectively. Kapur refers to a number of previous empirical studies of his own that resulted in improved performance on procedural fluency and complex analysis problems and "in adapting and building upon the targeted concepts to learn new concepts on their own" (p. 2728). Roll et al. (2011) explain positive results of a study on "invention" activities, which involve the same structure and purpose as PF designs. Reasons for enhanced learning include that "students may learn better from failures of methods they designed since they understand the intended function of each component in their methods" (p. 2827). Furthermore, in a study resulting in improved memory retention among participants who exhibited a state of 'surprise' when presented with information contrary to their initial assumptions in a "prediction" task (Brod et al., 2018), enhanced learning effects were attributed to the process of generating a prediction, which "enables the learner to be surprised about outcomes that refute the prediction, and ... this surprise leads to an updating of knowledge structures" (p. 28).

A common theme among the conclusions drawn from these related methods is that initially eliciting students' prior knowledge serves to draw their attention towards the significance of necessary features of targeted concepts that they had not yet known before. Collectively, the explanations of learning processes here surmount to a precise, comprehensive depiction of how active learning can work, and this can be useful in that it might be applicable to the design of methods in other educational contexts. A consideration, then, is whether or not the PF process could be related to and implemented in a language learning context. As the following section will show, very similar depictions of cognitive development to that attributed to the PF process exist in literature on L2 output production in 'negotiation of meaning' situations. How this can be applied to design methods for use in the language classroom is also explained in a later section.

How the 'PF' Design Relates to L2 Output Production in a Communicative Situation

The interplay between prior knowledge and new incoming information in the development of schemata, and the value of deliberately activating prior knowledge in advance of introducing new concepts in educational settings can be associated with language learning. Producing linguistic output in a communicative context as a means of exchanging information with others can be thought of in terms of how learners might build upon their interlanguage through this process. Relating output production to the PF design and schema development might allow for the same theorizing to be applied to foreign language education: a learner's interlanguage, the current state of

declarative and procedural L2 knowledge in their mind, can be thought of as a schema, a schema for sociocultural discourse in the target language; and any attempt at trying to utilize this schema to formulate a deliverable message is similar in nature to the 'invention' or 'generation' phase of a productive failure task. What a learner generates is an assumption of how their linguistic knowledge can be applied to fulfill the communicative act they are attempting. Expressing this, they expose what they know and do not know about the language, giving a more proficient or knowledgeable interlocutor the opportunity to provide knowledge in response to apparent mistaken or lacking constituents of an underdeveloped schema. In this, there is a similarity to the differentiation that Kapur describes. Learners must activate prior knowledge to some extent to construct a message, deliberately or automatically arranging linguistic elements to construct meaning. Initially expressing this sort of crude sample of their target language knowledge allows them to then compare (or 'differentiate') it with evidence of more accurate, complex or precise language use available in input sources, such as proficient interlocutors or textual content (or peers referring to texts to provide scaffolding, which will be explained more in the section on information gaps). Studies and discussions stemming from Swain's (1985) 'output hypothesis' also contain depictions of potential benefits of attempting accurate L2 production and reacting to resulting feedback. Swain and Lapkin (1995) explain how not only input, but also output can contribute to acquisition:

> when, as a result of producing the target language, learners 'notice' a problem, they conduct an analysis leading to modified output. That is, noticing may occur because of either internal or external feedback which may prompt, for example, the generation of alternatives and assessment of them through simple inspection through to complex thinking. When learners cannot work out a solution, they may turn to input, this time with more focused attention, searching for relevant input. Or, they may work out a solution, resulting in new, reprocessed output. What goes on between the first output and the second, we are suggesting, is part of the process of second language learning (p. 386)

The process is considerably 'active' on the learner's part. If generating output leads them to "turn to input … with more focused attention" (p. 386), the experience may prime them to comprehend and acquire the input more thoroughly in the way that PF activities "activate students' thinking about the concept" (Kapur & Rummel, 2012, p. 649), having them "explore and generate a variety of representations and methods" (Kapur, 2010, p. 2728), allowing them to "attend to critical features of the targeted concepts" (p. 2728) because they "understand the intended function of each component in their methods" (Roll et al., 2011, p. 2827). In a linguistic sense, since they intend to communicate something in particular with their initial utterance, the conceptuality here would suggest that the features of corrective feedback will be understood more thoroughly as their meaning and function can be acknowledged in connection with the learner's initial thought processes. One arguable difference is that during 'invention' or PF activities, students are conscious of the fact that the intent is to acquire a method, whereas instances of an output-feedback-modified output cycle could be quite fleeting and not consciously noted as an opportunity to develop language knowledge. Some significance, however, can be attributed to the dynamic cognitive activity involved. If learners were to become accustomed to such a process and engage in it frequently, it might foster in them a more active, intuitive attitude

towards learning through using the language as opposed to regarding live communication as a time for just 'getting by' or 'making do' with limited expressive resources, excluding a focus on the opportunity to build on one's interlanguage with the linguistic information made available in the social discourse.

More details on the cognitive activity involved when learners "conduct an analysis leading to modified output" (Swain & Lapkin, 1995, p.386) reveal how enhanced attention and contemplation might occur, even if on a small scale. If feedback is received, the input from this feedback provides grounds for more thorough monitoring when re-attempting formulation of a previously unsatisfactory utterance (Sato & Lyster, 2012, p. 595). Reflecting on the lower performance of study participants exposed only to enhanced input compared to those who produced output as means of understanding English relativization, Izumi (2002) points out that only decoding input can be achieved without focusing on the grammatical relationships between structural elements, stating that "unless one perceives the relationship among related form elements, morphological concordances may never be acquired" (p. 571). In output production, the piecing together of elements is executed by the learner. They are "responsible for message generation and formulation that requires grammatical encoding" (Izumi, 2003, p. 183) and, as a result of Izumi's (2002) study, "the output task served effectively both as the stimulator of integrative processing and as the glue to connect individual form elements" (p. 571). The cognition activated when learners engage in this sort of 'invention' or 'generation' followed by exposure to contrasting information seems to involve deeper schematic adjustment and increased attention to the meaning, function and relation of crucial features of a concept. For language learning, the 'concepts' would include inflectional or structural attributes of the target language.

It might seem, then, that the way to cash in on all of these wondrous learning effects in the language classroom would simply be to have students produce more speech or writing. However, not all forms of learner output will automatically involve effective degrees of monitoring and contemplation as described above, or instigate sufficient feedback to scaffold a reflective assessment of one's interlanguage. In most cases, quite specific conditions and activity parameters would probably be required to steer learners towards engaging in constructive L2 dialogue at a complexity level adequate to both operate and challenge their current linguistic resources. Swain (1985) notes that producing output can involve "simply getting one's message across[, which] can and does occur with grammatically deviant forms and sociolinguistically inappropriate language" and argues that learners need to be "pushed toward the delivery of a message that is not only conveyed, but that is conveyed precisely, coherently and appropriately" (p. 248-249). This would be more likely to compel learners to give attention to the linguistic accuracy of their utterances and any available contrastive input. It is worthwhile, then, to consider how teachers might go about designing activities that instigate multiple instances of 'pushing' learners to engage in *effective* output production and constructive negotiation of form or meaning.

To involve the factors discussed here in learning processes in the language classroom, a complexity of both input and output content that can adequately stimulate deepening of L2 knowledge or solidification of expressive skills needs to be prompted by setting activity parameters that instigate on topic formulation of multi-word utterances and

incorporate target language sourced feedback as part of the procedure involved in executing the activity. The information gap activity is one type of construct that can be applied to incorporate this. Therefore, to elaborate on the depiction of the potential function of a guessing style of information gap, the following section explains an example of an activity intended to engage learners in production of 'pushed' output and instigate constructive negotiation of meaning.

How the Information Gap Activity Construct Can Elicit 'Pushed' Output and the Potential Learning Processes Involved

In the following, an example of the style of information gap referred to in the introduction of this paper will be evaluated for its potential to instigate output-feedback-modified output cycles in which learners' interlanguage resources can be contrasted with target language content in a way that resembles the differentiation aspect of the productive failure learning design. The topic of this example activity is 'World Records', particularly odd or surprising ones that might be fun for students to talk about. A selection of texts explaining a collection of such records found on the internet can be printed on cards and dispersed among members of a small group. These are the 'answers' to the information gaps, so should be kept secret at first. Students are then shown only small and incomplete bits of information about one of the records on a screen or blackboard. An example would be 'shoe', '6.4', '2.39', '1.65' (adapted from Guinness World Records, 2020), as in 'Figure 1' below:

Figure 1: Example display from the 'World Records' information gap activity

One member of a group will notice that their card has the answer on it, and other members should take turns trying to say what they think the record is, having been directed that they must include all of the information on the screen in their answer. The learners, then, are producing output, and it is 'pushed' output as they need to consider how to express the dimensions of the shoe and syntactically formulate sentences that refer to this as a record. The context and content of the activity and this particular prompt demand a certain degree of linguistic precision to effectively communicate guesses at what might fill out the information gap. Depending on their proficiency, students could express their thoughts at different levels of complexity, and they can be told that they do not have to say it exactly as in the answer text. They might say, "It is a very big shoe that is ~ meters wide, ~", or use more complex structure and vocabulary to say, "The largest shoe ever made is ~". Although it cannot be guaranteed, it is also possible that the group member holding the answer might

provide feedback on the format of the targeted text if guessing students' output is overly imprecise or inaccurate. There is also potential for feedback to be given on the suitability or morphology of lexical items in output that correspond with the equivalent message in the input text (the answer). An example of a possible occurrence of this is represented in 'Figure 2' below:

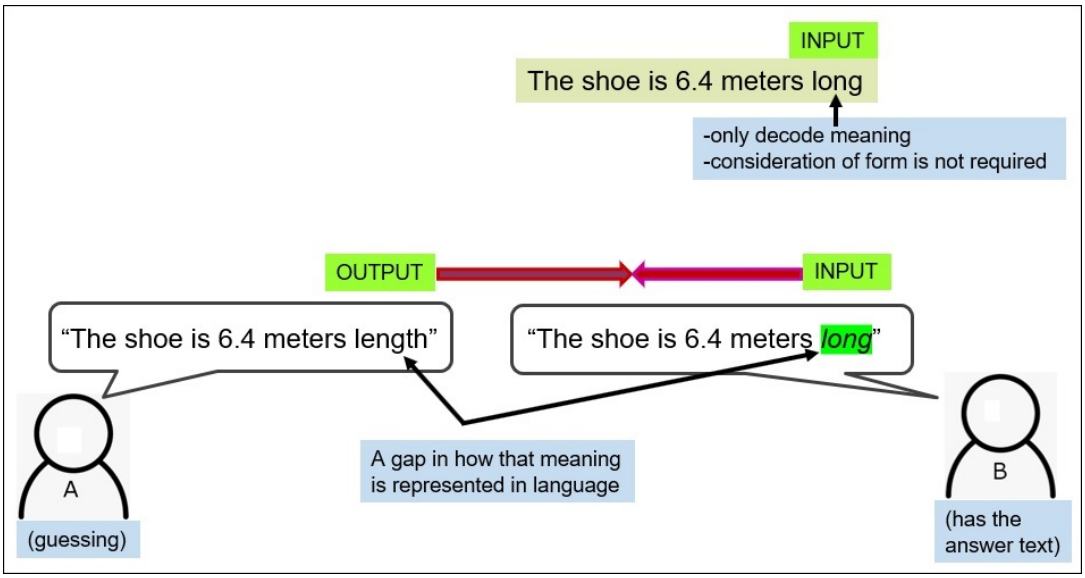

Figure 2: Diagram of possible output-feedback contrasting

As opposed to only comprehending meaning, the contrast which may become evident to learners in comparing output with feedback might draw attention to differences in how that meaning is represented linguistically. Syntactic, morphological and lexico-grammatical differences between a learner's interlanguage resource and the target language text of the information gap can be made salient through learner interaction in an activity such as this. Finally, the process will be further enhanced if following attempts at 'modified output' are made if any contrasting feedback is regarded as indicating a need for alterations or additions to the anomalous output produced in the initial attempt. Relating this to the PF design, it is this initial anomalous attempt that constitutes the 'failure'. This failure is a linguistic failure due to the in-development status of a learners L2 linguistic knowledge, not a failure in communicating meaning, which, to repeat the previous reference to Swain (1985), "can and does occur with grammatically deviant forms and sociolinguistically inappropriate language" (p. 248-249).

Conclusion

The point is not that activities should follow the typical information gap structure, but that the information gap construct embodies the elicitation of *pushed* output from learners. It might be beneficial, therefore, to have activities that incorporate some way of eliciting learners' interlanguage before exposing and analyzing the corresponding content in the target language. In a more open communicative activity, learners can choose to leave difficult content out of the discourse, but with an information gap incorporated, the predetermined discourse (the answer to the 'gap') demands a certain level of complexity and accuracy for output to be relevant. As this resembles the 'productive failure' design, it reveals the active learning essence of the information gap concept.

Functioning in the way that ‘productive failure’ designs do, it is possible that this output-first pattern embodied in the activity introduced earlier may provide a deeper learning experience involving more insightful understanding of the functions and purposes of forms in the target language than if learners only receive direct instruction. Learners need to be immersed in the meaning-context of the content when they contribute their own output to the discourse instead of passively analyzing that discourse as an alien phenomenon that does not involve their internal knowledge and thoughts. Any input really does involve the learner, though, and it should, as they need to develop agency in the conscious development of their interlanguage as a real tool for real communication.

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