The project enhanced here was implemented at a private collage in a physics course during the spring 2009 semester. The students generally responded quite enthusiastically to this collaborative-developing structure. I think my students, especially the experiment group, developed expertise in the use of this project based learning activity in which they acquired information and build skills while investigating a real-world issue. In fact, it can be considered as a semi-collaborative activity since not all students actively participated in conducting the experiment.

Other instructors can try this activity. Withthe same starting point,but depending on class discussions they can follow another path and can end up with another solution. What I want to emphasize is that with such activities, teachers can prepare their students for project competitions. Moreover, we have to teach our students, if we are sure about a problem, we have to struggle until we get desired solution.

On the other hand, this experience can be considered as a complete collaborative learning activity. The teacher can introduce the problem; the students can discuss possible solutions,and the teacher can set up groups, and then assignsproposed solution to the groups. Once each group brought their results they can discuss the conclusions and decide about the best solution. Finally, this project based activity can be conducted with 5E learning cycle.

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ЖОБА ИДЕЯСЫН НЫҒАЙТУ ЖӘНЕ СТУДЕНТТЕРДІ БЕРІЛМЕУГЕ ҮЙРЕТУ

Андатпа: Жоба негізделген оқыту, немесе оқу-іректке негізделген процессі, енжар ақпарат алудан гөрі, оқушылардың өз оқуын салу процессі болып табылады. Оның үстіне, ол студенттер мен оқытушылар үшін де қызықты болып табылады. Бұл мақалада оқу-іректке негізделген процессін сыныпта сипаттай отыра, студенттерді жобаны дамытуында қадам қадам бағыттандырдым. Жобаны құру кезінде қиындықтарды жеңуге, еш берілмеуге үйрете отыра, кез келген қолайсыз жағдайларда жобадан бас тартпауға қолдау бердім.

Кілт сөздер: жоба, процессі, студенттер, қиындықтар.

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ОБУЧЕНИЕ ПРОЯВЛЕНИЯ АКТИВНОСТИ СТУДЕНТОВ ПРИ РАЗРАБОТКЕ НАУЧНЫХ ПРОЕКТОВ

Аннотация: Проектное обучение или обучение на основе деятельности представляет собой процесс, в котором студенты строят свое собственное обучение, а не пассивно получают информацию. Более того, это интересно как для студентов, так и для преподавателей. В данной статье автор описал деятельность на уроке, в которой направлял студентов шаг за шагом к разработке проекта. Чтобы преодолеть трудности во время создания проекта, исследователь поддерживал их не отказываться и не сдаваться от проекта при любых неблагоприятных обстоятельствах.

Ключевые слова: проект, процесс, студенты, трудности

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SOME PROPERTIES OF FINITELY QUILTED ORDERED STRUCTURES

Abstract: It is knownthat any cut in an o-minimal structure has a unique extension up to a complete type over the model. For weakly o-minimal structures a cut can have at most two extensions up to complete types, and the sets of realizations of these types are convex in any elementary extensions. Generalizing weak o-minimality we obtain the following notion of an *n*-quilted structure: a totally ordered structure is said to be n-quilted if any cut has at most *n* extensions up to complete types. Note that we omit here condition that the set of all realizations of a type must be convex. In this article we investigate basic properties of *n*-quilted structures.

Since notion of o-minimality had appeared in [1] a series of generalizations were suggested such as weak o-minimality, quasi-o-minimality, almost o-minimality, quasi weak o-minimality, C-minimality, variants of o-minimality and others.

Key words: Mathematical logic, model theory, o-minimality, ordered structures, a cut, a complete type.

Here we suggest a new notion of a finitely quilted structure. But before we explain why we suggest this notion.

Definition 1 [1] *A totally ordered structure* $(M,<,\dots)$ *is called o-minimal if for any formula* $\varphi(x,\overline{y})$ *and any parameter* $\overline{a}$ *the set* $\varphi(M,\overline{a})$ *is a finite union of intervals and points.*

It is well known that a totally ordered structure is o-minimal iff any cut has a unique extension up to a complete type.

Definition 2[2] *A totally ordered structure* $(M,<,\dots)$ *is called weakly o-minimal if for any formula* $\varphi(x,\overline{y})$ *and any parameter* $\overline{a}$ *the set* $\varphi(M,\overline{a})$ *is a finite union of convex sets.*

Theorem 3[3] $(M,<,\dots)$ *is weakly o-minimal if and only if for any cut* (C,D) *there are at most two complete types extending* (C,D) *and if there are two types then the set of realizations of these two types in any elementary extensions are convex.*

So we see that the number of extensions of a cut characterize weak o-minimality. That is why the following definition is quite natural.

Definition 4 *A totally ordered structure* $(M,<,\dots)$ *is called* n*-quilted if any cut in* M *has at most* n *extensions to complete types over* M*. A totally ordered structure is called finitely quilted if it is n-quileted for some natural number n.*

Obviously, any weakly o-minimal structure is 2-quilted.

Now we give an example of a 2-quilted structure which is not weakly o-minimal.

Example 5 $M=(\mathbb{R},<,Q);\ M\vDash Q(a)\Leftrightarrow a\in\mathbb{Q}$.

Theorem 6 *The elementary theory of* $(R,<,Q)$ *admits quantifier elimination.*

Proof: First we write axioms for $(R,<,Q)$:

1) $\forall x\forall y(x<y\rightarrow y\nless x)$;

2) $\forall x\forall y\forall z(x<y\wedge y<z\rightarrow x<z)$;

3) $\forall x\forall y(x<y\vee x<y\vee x>y)$;

4) $\forall x\exists y(y<x)$;

5) $\forall x\exists y(x<y)$;

6) $\forall x\forall y\exists z(x<y\rightarrow x<z\wedge z<y)$;

7) $\forall x\forall y\exists z(x<y\rightarrow x<z\wedge z<y\wedge Q(z))$;

8) $\forall x\forall y\exists z(x<y\rightarrow x<z\wedge z<y\wedge\neg Q(z))$.

By Tarski's test it is sufficient to eliminate existential quantifier in a formula of the form $\exists x\bigvee_{i=1}^{n}\varphi_i(x,\overline{y}_i)$, where φ_i are literals, that is of the form

$$x = y, x \neq y, x < y, x \not\leq y, x > y, x \not\geq y, Q(x), \neg Q(x).$$

Observe that we have the following equivalences:

$$x \neq y \Leftrightarrow (x < y) \vee (x > y);$$
$$xy \Leftrightarrow (x = y) \vee (x > y);$$
$$xy \Leftrightarrow (x < y) \vee (x = y).$$

So if we consider $\exists x(x \neq y \wedge \varphi(x,\overline{y}))$. This is equivalent to

$$\exists x(((x < y) \vee (y < x)) \wedge \varphi(x,\overline{y})).$$

We open parenthesis by distributive low:

$$\exists x[((x < y) \wedge \varphi(x,\overline{y})) \vee ((x > y) \wedge \varphi(x,\overline{y}))]$$

And this is equivalent to

$$\exists x((x < y) \wedge \varphi(x,\overline{y})) \vee \exists x((x > y) \wedge \varphi(x,\overline{y}))$$

Now we can eliminate these quantifiers separately. So we may assume that we do not have φ_i of the form $x \neq y, x \leq y, x \geq y$. Similarly,

$$((x < y) \wedge (x < z)) \Leftrightarrow ((x < y) \wedge (y < z)) \vee ((x < z) \wedge (yz))$$

So we may assume that at most one of φ_i's is of the form $x > y$.

$$\exists x((x < y) \wedge (x < z) \wedge \varphi(x,\overline{y})) \Leftrightarrow$$
$$\exists x[(((x < y) \wedge (y < z)) \vee ((x < z) \wedge (yz))) \wedge \varphi(x,\overline{y})] \Leftrightarrow$$
$$\exists x[((x < y) \wedge (y < z) \wedge \varphi(x,\overline{y})) \vee ((x < z) \wedge (yz) \wedge \varphi(x,\overline{y}))] \Leftrightarrow$$
$$\exists x((x < y) \wedge (y < z) \wedge \varphi(x,\overline{y})) \vee \exists x((x < z) \wedge (yz) \wedge \varphi(x,\overline{y})) \Leftrightarrow$$
$$[\exists x((x < y) \wedge \varphi(x,\overline{y})) \wedge (y < z)] \wedge [\exists x((x < z) \wedge \varphi(x,\overline{y})) \wedge (yz)]$$

If one of φ_i's is $x = z$ formula $\exists x \bigvee_{i=1}^{n} \varphi_i(x,\overline{y}_i)$ is equivalent to $\bigvee_{i=1}^{n} \varphi_i(z,\overline{y}_i)$, which is quantifier-free. So we may assume that there is no φ_i of the form $x = y$.

Thus we have the following kinds of formulas:

1.1$\exists x((y < x < z) \wedge Q(x))$;

1.2 $\exists x((y < x < z) \wedge \neg Q(x))$;

1.3 $\exists x(y < x < z)$;

2.1$\exists x((x < z) \wedge Q(x))$;

2.2$\exists x((x < z) \wedge \neg Q(x))$;

2.3$\exists x(x < z)$;

3.1$\exists x((y < x) \wedge Q(x))$;

3.2$\exists x((y < x) \wedge \neg Q(x))$;

3.3$\exists x(y < x)$;

4.1$\exists x(Q(x))$;
4.2$\exists x(\neg Q(x))$.

By axiom (7) the formula 1.1 is equivalent to $y < z$.The formula 1.2 is equivalent to $y < z$ by axiom 8.The formula 1.3 is equivalent to $y < z$ by axiom 7.By axioms 4 and 6,7,8 the formulas 2.1, 2.2, 2.3 are true, that is equivalent to z = z.Similarly 3.1, 3.2, 3.3 are equivalent to y = y by axioms 5, 6, 7, 8.4.1 is equivalent to y = y by axiom 7 and 4.2 is equivalent to y = y by axiom 8.

Consider any cut $\langle C, D\rangle$. Let φ be consistent with $\langle C, D\rangle$. By quantifier elimination φ is $C < x, x < d, Q(x), \neg Q(x). x = a$. Since formulas $c < x$ and $x < d$ already belongs to $\langle C, D\rangle$ if $c \in C, d \in D$.So the only way to extend the is to add $Q(x)$ or $\neg Q(x)$. Thus we have that each cut has exactly 2 extension, so this structure is 2-quilted.

Example 7 $(\mathbb{R}, <, Z)$ *is 2-quilted. Any bounded cut has a unique extension, the cuts* $+\infty = \langle R, \emptyset\rangle$ *and* $-\infty = \langle \emptyset, R\rangle$*are consisted with* $Z(x); \neg Z(x)$.

Example 2.7 is similar to the example 2.6.

Now we give an example of a 2-quilted structure which is not weakly quasi o-minimal.

Let $M = \mathbb{Q} \cup (\mathbb{Q} + \pi)$ and $\Sigma = \{=, <, P^2\}$. the order $<$ on M is the restriction of the natural order on $\mathbb{R}$ to M. If $a \in \mathbb{Q}$ then $P(M, a) = (a - 1, a + 1) \cap \mathbb{Q}$, otherwise $P(M, a) = (a - 1, a + 1) \cap (\mathbb{Q} + \pi)$.

Also we define function $s(x)$ as $s(a) = supP(M, a)$

$$y = s(x) \Leftrightarrow \forall z(P(z,x) \to z < y) \wedge \forall t[\forall z(P(z,x) \to z < t) \to y \leq t]$$

Theorem 8$Th(M, <, P, s, s^{-1})$ *admits quantifier elimination.*

Proof: Any term has the following form: $s^n(x)$,where $n \in Z$. So we have the following literals:

1. $s^n(x) = s^k(y)$;
2. $s^n(x) \neq s^k(y)$;
3. $s^n(x) < s^k(y)$;
4. $s^n(x) s^k(y)$;
5. $s^n(x) > s^k(y)$;
6. $s^n(x) s^k(y)$;
7. $P(s^n(x), s^k(y))$;
8. $\neg P(s^n(x), s^k(y))$.

Similarly to Theorem 6 we may assume that in $\exists x \bigvee_{i=1}^{n} \varphi_i(x, \overline{y}_i)$ there is no φ_i of the forms 2, 4, 6.

Note that $s^n(x) = s^k(y)$ is equivalent to $s^{n+m}(x) = s^{k+m}(y)$ for any $m \in Z$ and $P(s^n(x), s^k(y))$ if and only if $P(s^{n+m}(x), s^{k+m}(y))$ for any $m \in Z$. So we may assume that n in each φ_i is the same and $n = 0$. If at least one of $\varphi_i(x, y)$ is one of the form $s^n(x) = s^k(y)$ then

$$\exists x \vee_{i=1}^{n} \varphi_i(s^n(x), \bar{y}_i) \Leftrightarrow \vee_{i=1}^{n} \varphi_i(s^k(y), \bar{y}_i).$$

Thus we may assume that no φ_i of the form $s^n(x) = s^k(y)$. Also we may assume that at most one φ_i of the form 3 and 5. So the general form is

$$\exists x(s^m(y_1) < x < s^k(y_2) \wedge \vee_i P(x, z_i) \wedge \vee_j \neg P_j(x, u_j)).$$

Note that $P(x, z_1) \wedge P(x, z_2)$ is equivalent to $P(x, z_1) \wedge s^{-1}(z_2) < x < s(z_2) \wedge (P(z_2, z_1) \vee P(s(z_2), z_1) \vee P(z_2, s(z_1)))$. So we may assume that at most one φ_i is of the form $P(x, z)$.

$$\begin{aligned} P(x,z) \wedge \neg P(x,y) \Leftrightarrow\ & P(x,z) \wedge [x < s^{-1}(u) \vee x > s(u) \vee (s^{-1}(u) < x < s(u) \wedge \neg P(x,u))] \\ & \Leftrightarrow (P(x,z) \wedge x < s^{-1}(u)) \vee (P(x,z) \wedge x < s(u)) \vee (P(x,z) \wedge s^{-1}(u) < x \\ & < s(u) \wedge \neg P(x,u)) \Leftrightarrow (P(x,z) \wedge x < s^{-1}(u)) \vee (P(x,z) \wedge x \\ & < s(u)) \vee P(x,z) \wedge s^{-1}(u) < x < s(u) \wedge (P(z,u) \vee P(s(z),u) \vee P(z, s(u)))] \end{aligned}$$

$$P(x,z) \wedge s^{-1}(u) < x < s(u) \wedge \neg P(z,u) \wedge \neg P(s(z),u) \wedge \neg P(z, s(u))$$

So if we have at least one φ_i of the form $P(x, z)$ we may assume that there is no φ_1 of the form $\neg P(x, u)$. Consider

$$\exists x(s^m(y_1) < x < s^k(y_2) \wedge P(x,z))$$

which is equivalent to $\exists x(s^m(y_1) < x < s^k(y_2) \wedge s^{-1}(z) < x < s(z) \Leftrightarrow s^m(y_1) < s^k(y_2) \wedge s^m(y_1) < s(z) \wedge s^{-1}(z) < s^k(y_2) \wedge s^{-1}(z) < s(z)$.

So it is sufficient to consider

$$\exists x(s^m(y_1) < x < s^k(y_2) \wedge \vee_{j=1}^{2} n \neg P(x, u_j)) \Leftrightarrow$$

$$\begin{aligned} s^m(y_1) < s^k(y_2) \wedge [s^{m+4n}(y_1) < s^k(y_2) \vee (s^{m+4n}(y_1) > s^k(y_2) \wedge \neg \vee_{\tau \in s_{2n}} (s^{-1}(u_{\tau(1)}) \\ \le s^m(y_1) \wedge s^{-1}(u_{\tau(2)}) \le s(u_{\tau(1)}) \wedge s^{-1}(u_{\tau(3)}) \le s(u_{\tau(2)}) \wedge \ldots \wedge s^{-1}(u_{\tau(n)}) \\ \le s(u_{\tau(n-1)}) \wedge s(u_{\tau(n)}) \\ \ge s^k(y_2) \wedge P(u_{\tau(1)}, u_{\tau(2)}) \wedge P(u_{\tau(2)}, u_{\tau(3)}) \wedge \ldots \wedge P(u_{\tau(n-1)}, u_{\tau(n)}) \wedge s^{-1}(u_{\tau(n+1)}) \\ \le s^m(y_1) \wedge s^{-1}(u_{\tau(n+2)}) \le s(u_{\tau(n+1)}) \wedge s^{-1}(u_{\tau(n+3)}) \le s(u_{\tau(n+2)}) \wedge \ldots \wedge s^{-1}(u_{\tau(2n)}) \\ \le s(u_{\tau(2n-1)}) \wedge s(u_{\tau(2n)}) \\ \ge s^k(y_2) \wedge P(u_{\tau(n+1)}, u_{\tau(n+2)}) \wedge \ldots \wedge P(u_{\tau(2n-1)}, u_{\tau(2n)}) \wedge \neg P(u_{\tau(1)}, u_{\tau(n+1)})))] \end{aligned}$$

From quantifier elimination it is easy to prove that the considered structure is 2-quilted.

Obviously, any finitely quilted structure is o-ω-stable. Since any o-stable ordered group is Abelian and divisible [4], we obtain that any finitely quilted ordered group is Abelian and divisible.

Lemma 9 Let G be an ordered finitely quilted groups. Then any definable subgroup is convex.

Proof. Assume the contrary, that a definable subgroup H of the group G is not convex. Since G is divisible the subgroup H has the infinite index in its convex hull. So the cut which is defined by sup$H$ has infinitely many extensions by formulae $H(x) + g$.

Theorem 10 Let G be an ordered finitely quilted groups as well as its any elementary extensions. Then Th(G) is weakly o-minimal.

Proof. Assume that a definable subset A has infinitely many convex components. Let a cut $\langle C, D \rangle$ be consistent with both A and the complement of A. This cut does exists, becouse the set A

has infinitely many components. Consider an infinitesimal element b in some elementary extensions, such that for any c, realizing the cut $\langle C, D\rangle$ the element $b + c$ also realizes this cut. Fix som sufficiently saturated elementary extension and consider cuts defined by sup$C$ and inf$D$. It is easy to see that the definable sets $A + nb$are consistent with these cuts for any natural nunmber n. For details one can see [5]. So this cut has infinitely many extensions up to complete types.

Question Is there a 2-quilted ordered group which is not weakly o-minimal?

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НЕКОТОРЫЕ СВОЙСТВА КОНЕЧНО ПРОСТЕГАННЫХ УПОРЯДОЧЕННЫХ СТРУКТУР

Аннотация: Известно, что любое сечение в о-минимальной структуре имеет единственное расширение до полного типа над моделью. Для слабо о-минимальных структур сечение может иметь максимум два расширения до полных типов, причем множества всех реализаций этих типов являются выпуклыми в любых элементарных расширениях. Обобщая слабую о-минимальность, получаем следующее понятие n-стеганых структур: линейно упорядоченная структура называется n-стеганой, если любое сечение имеет не более n расширений до полного типов. Обратите внимание, что мы здесь опускаем условие, что множество всех реализаций типа должно быть выпуклым. В этой статье мы исследуем основные свойства n-стеганых структур.

Ключевые слова: математическая логика, теория моделей, о-минимальность, упорядоченные структуры, сечение, полный тип.

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ВОПРОСЫ ОРТОГОНАЛЬНОСТИ И НЕРАЗЛИЧИМОСТИ В СЛАБО ЦИКЛИЧЕСКИ МИНИМАЛЬНЫХ СТРУКТУРАХ

Аннотация: В настоящей работе исследуются циклически упорядоченные структуры с условием слабой циклической минимальности. Найдены необходимые и достаточные условия неразличимости множества реализаций неалгебраического 1-типа в счетно категоричных слабо циклически минимальных структурах.

Данная статья направлена на рассмотрение понятия *слабой циклической минимальности*, введенного и первоначально глубоко исследованного, на вопросы неразличимости множества в слабо циклически минимальных структурах. В работе